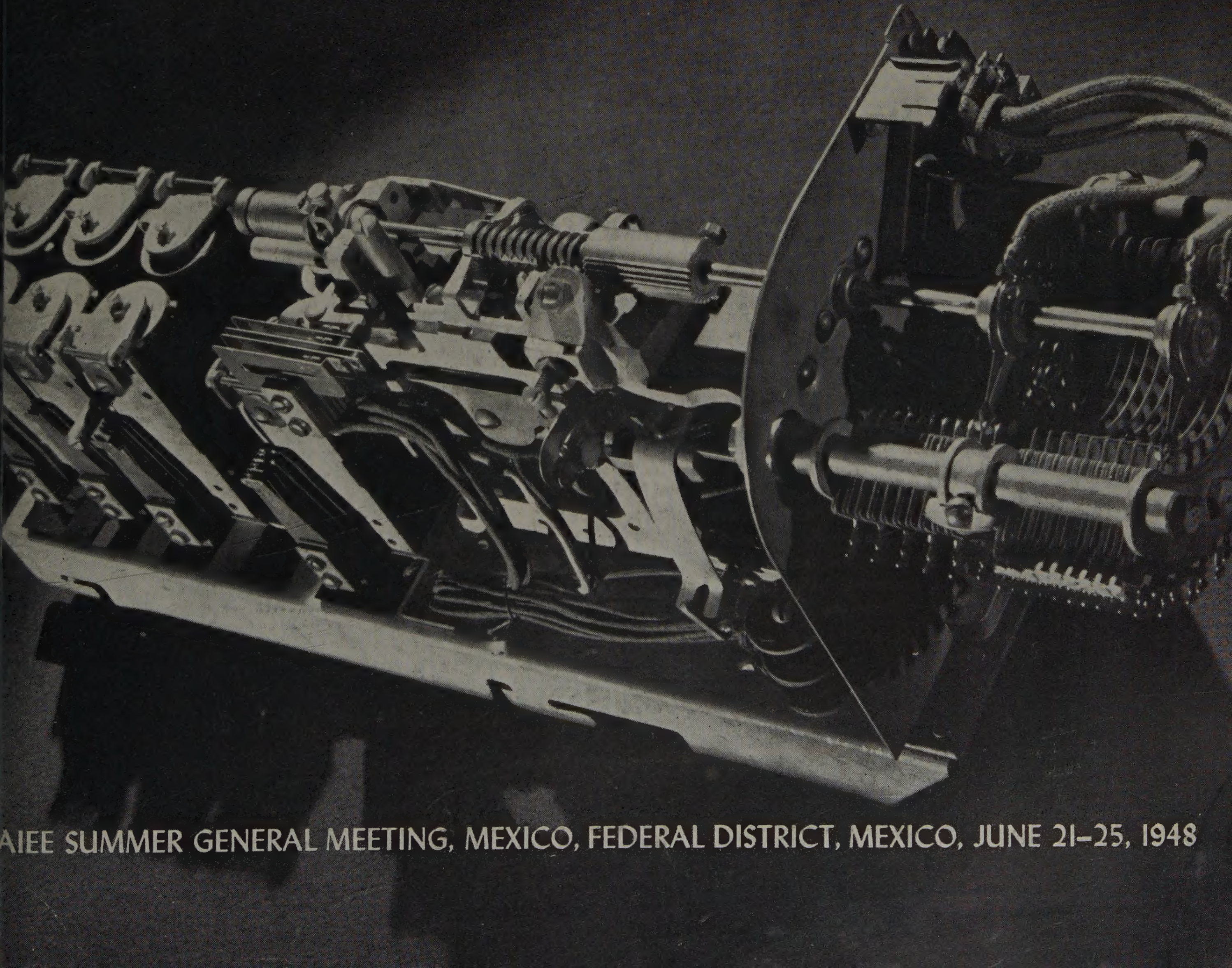
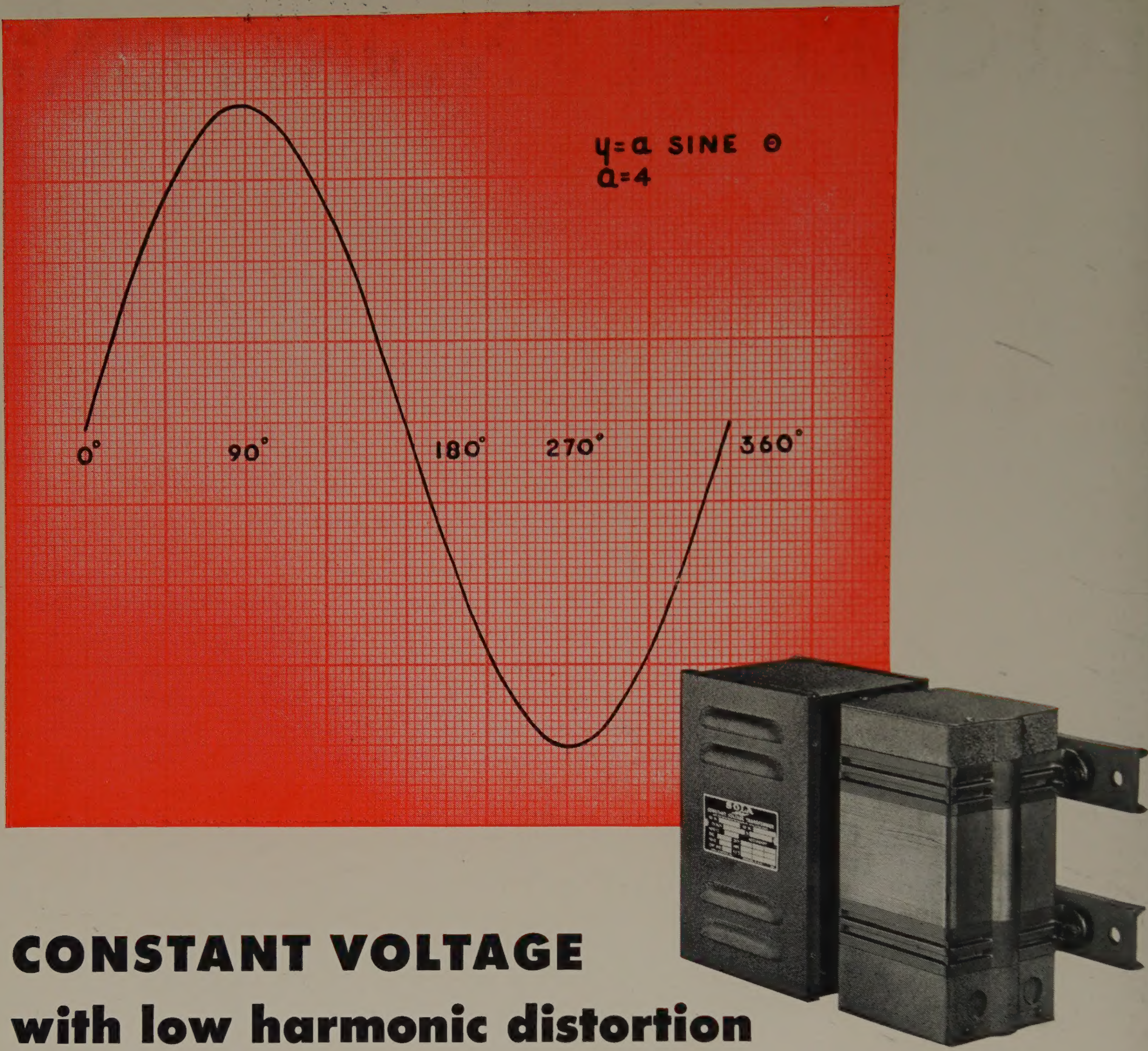
ELECTRICAL ENGINEERING

JUNE 1948



IEE SUMMER GENERAL MEETING, MEXICO, FEDERAL DISTRICT, MEXICO, JUNE 21–25, 1948



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JUNE

1948

The Cover: The Strowger switch, an important piece of equipment in the "Director" for automatic telephone switching systems described in this issue (*pages 539–48*).

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WIREMAKER FOR INDUSTRY

Telegraph Development in Mexico

JOSE HERNANDEZ OLMEDO
ASSOCIATE AIEE

A recent survey of the telegraph and telephone facilities of Mexico showed that equipment was old, in poor condition, and insufficient. An over-all improvement program calls for rewiring overloaded principal lines, installation of up-to-date central office equipment, replacement of transmitters and receivers for radiotelegraphy, and other modernization steps.

THE telegraph and radiotelegraph communications system of the Mexican Republic are government-controlled and are subject to the dispositions and orders of the Ministry of Communications and Public Works. They serve the public as well as transmitting all official government messages. The Department of Telegraph Communications of the Ministry of Communications and Public Works is in charge of the systems.

Development of the systems throughout the country has been slow and costly because of the difficult nature of the terrain in many regions. As a result some parts of the nation have no direct telegraph communication with the capital. Among these are: Villa Hermosa, Tabasco; Mérida, Yucatán; and the peninsula of Lower California. All such districts as well as many places of varying importance would not be able to communicate readily with the rest of the country if it were not for radiotelegraph stations installed in those isolated regions which permit direct and indirect communication with the outside world.

The introduction of telegraph service in Mexico dates back to the year of 1852 when the first communication systems were installed by private companies backed in part by the government. Considerable difficulties were met to establish these early communication systems which subsequently were heightened by politics and by adverse economic conditions. As a consequence, the concessionaires experienced many very trying periods and no radical improvements were introduced in the systems until 1878 when the Department of Telegraphs, then a dependency of the Secretaría de Fomento, was created which took over their administration.

By 1866, the system covered 23,000 kilometers with 211 telegraph offices in operation. Besides this system called the National Lines, several independent lines came into existence, established by state governments, by the railways, and by private companies through concessions granted by the Department of Telegraphs and permitted to operate under its jurisdiction.

For many years, overland telegraph communications systems employed galvanized iron wire conductors because of their low cost. Practically all the lines operated on the simple system of ground circuits. The national telegraph system consists of a series of trunk lines leading out from a central office in the capital to various distant points or terminals with intermediate offices along the routes. Many of these intermediate offices, generally the most important ones, serve as subcentral stations, because aside from being in direct communication with the capital they also are connected with local lines and feeders which permit communication with points more or less close by and which are not serviced by the principal lines. There are also many small lines operated by some telegraph offices which are utilized both for telegraph and telephone communication simultaneously over a single wire. Finally, there exist some lines used for telephone purposes only such as those of Jiquilpan Michoacán; Sahuayo, Michoacán; Uruapan, Michoacán; and Apatzingan, Michoacán, which serve as the local telephone system and which are capable of being united by long distance with Morelia, Michoacán; Mexico, Federal District; and so forth.

It was not so very long ago that the lines utilized gravity cells for their source of power, both on their trunk lines and on local lines, and Morse sending and receiving instruments. During 1925, dynamos were installed in the principal offices and almost simultaneously simplex teletype instruments were introduced, with duplex and multiplex teletype being installed shortly afterwards.

Dynamos in many offices came into general use when towns and cities had their own power plants. Thermoelectric plants were installed for emergency purposes in case of interruptions or deficiencies in the public service power lines.

Bronze conductors were introduced after 1912 to replace the iron wire, particularly in those regions close to the coasts where the rapid oxidization of iron conductors required continuous replacements and repairs.

The introduction and installation of standard metallic circuits utilizing number 8 (Brown and Sharpe) copper wire was started in 1933 for the purpose of employing the carrier system of telephone and telegraph. The first carrier system was completed between Mexico City and Nuevo Laredo, Tamaulipas; it will be followed by one from Mexico City to Veracruz, Veracruz, another from Mexico City to Tampico, Tamaulipas, and still others from Guadalajara, Jalisco, to Navojoa, Sonora, and Mexico City to Acapulco, Guerrero, which permitted a simultaneously long distance telephone and telegraph service between these various points and the capital. A terminal telephone central station was established at Acapulco with intermediate

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Essentially full text of paper **48-156,** "Development of Telegraph Communications in the Republic of Mexico—Recently Approved Project to Change and Modernize the Present System," recommended by the AIEE communication committee and approved by the AIEE technical program committee for presentation at the AIEE summer general meeting, Mexico, Federal District, Mexico, June 21–25, 1948; and not scheduled for publication in AIEE *TRANSACTIONS.*

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central stations at Chilpancingo, Guerrero; Iguala, Guerrero; Taxco, Guerrero; and Cuernavaca, Morelos, connected with the local telephone services at each place.

The administration and operation of these local lines subsequently were turned over to the Ericsson Telephone Company.

Various other lines have been equipped with copper wire, and it is planned to extend these lines and condition them to complete new circuits.

RADIOTELEGRAPH

The first radiotelegraph tests were undertaken by the Department of Telegraphs from 1900 to 1902. Camilo A. González, then chief of the department, used some French model apparatus to make tests between the capital and Veracruz. Despite the deficiencies of these first models, the system proved its worth, so it was decided to utilize them to establish the first radiotelegraph communication with the peninsula of Lower California. During 1903, the first transmitting and receiving stations using the Slaby arc system were installed, one near the port of Guaymas, Sonora, and the other at Santa Rosalía, Lower California, at a distance of 150 kilometers over the ocean. These installations used an oscillating spark and a coherer detector. They were rated at $1^1/_2$ kw and were used experimentally until 1905 when the electrolytic cell detector was introduced which permitted fairly good communication. Immediately the service was made available to the public. After overcoming numerous technical problems and difficulties caused by climatic conditions, the stations constructed at Mazatlán, Sinaloa; San José del Cabo, Lower California; Payo Obispo, Quintana Roo; Kalak, Quintana Roo, were pressed into service. The first two stations connected the southern part of the peninsula of Lower California while the other two connected the territory of Quintana Roo over the lake of Chetumal. These were "telefunken" installations with 3-kw stations on the Pacific side and a 1/2-kw station in Quintana Roo.

The federal government in February 1909 adopted the recommendations of the international radiotelegraph convention which had been held in Berlin, October 1906.

The first real improvement in radio communication in Mexico occurred in 1911 when the telefunken system utilizing damped sparks and crystal detectors was introduced. This system was installed at Veracruz; Campeche, Campeche, and the Isla María Madre in the Pacific. The power of these stations was 1.5 kw. At the same time a new 2-kw station using the "wireless specialty" system was installed at Guaymas, Sonora, when fire destroyed the old wireless station there.

By that time nine wireless stations composed the national network which effectually aided overland communications and permitted communication with ships at sea. Thus, for the first time intercontinental communication was made possible in Mexico.

Radio regulations then were drawn up and put into force, with the national network adopting the call letter *X* to identify Mexican stations.

Political upheavals and disturbances from 1913 to 1917 brought about the installation of various radio stations and the dismantlement of others for strategic purposes. It was during this period that the value and efficiency of radio communication were recognized when it was used to substitute ordinary telegraph lines destroyed for the most part. It was at this time that the ships of the Mexican Navy were equipped with radio transmitters utilizing oscillator tube detectors.

Table I. Development of Radio Communication in Mexico

Period	Years	Description
1	1900–05	Experimental period. Spark transmitters and coherer detectors.
2	1905–11	Period of faulty communications. Damped spark transmitters and electrolytic cell detectors.
3	1911–15	Period of improvements. Damped spark transmitters and crystal rectifier detectors.
4	1915–23	Period of actual development, utilizing transmitters and receivers with oscillator tubes.

The powerful central transmitting station at Chapultepec, Mexico, was completed in 1918 which permitted direct radio communication with Europe and South America. This 200-kw station using the damped spark system was constructed solely by Mexican technicians.

Development of the national radio network continued unabated from 1918 to 1923 through the construction of many additional installations and the introduction of numerous improvements then considered to be the last word. Likewise the first short-wave transmitter was installed at Chapultepec and put into operation. It was a Radio Corporation of America 4-kw continuous wave transmitter. By the end of 1923 the radio telegraph network had 27 stations in operation.

Table I gives a breakdown of the development of radio communication in Mexico up to 1923, or during the first 23 years of operation.

As a consequence of World War II which seriously affected production in various countries and adversely affected their economic situations, little headway was made in carrying out improvements in telegraph communications from 1939 to 1945. About all that was possible during this period was maintenance work plus the construction of some installations required from national defense along the northwest coast with the port of Mazatlan being the central point of these operations. Table II gives the 1946 statistics.

THE IMPROVEMENT PROGRAM

When the present presidential term started in December 1946 and Agustín García López was appointed Minister of the Ministry of Communications and Public Works, he undertook to complete during his term of office all works that required immediate attention such as bringing up to date all telegraph communication systems in the country so that by installing modern apparatus, the service could keep abreast of the increasing demands upon it. The Department of Telegraphs reported on the state of existing installations, causes for inadequate service mainly because of old equipment and lack of sufficient circuits. A thorough investigation and study was made and a plan drawn up to start and complete all new installations and improve-

Table II.The Condition of Telegraph Communications During 1946

Ground Communications by Wire

Single telegraph and telephone line extensions, kilometers	41,787
Developed extensions of these lines, kilometers	113,363
(Copper wire conductor extensions total 23,901,429 kilometers, leaving an additional required 9,189 kilometers to complete the metallic circuits of the principal lines)	
Number of telegraph offices	659
Number of telephone offices	388
(45 of the 659 telegraph offices are equipped with telegraph printing apparatus)	

Cables

Class	Number	Single Lengths, Meters	Developed Lengths, Meters
Under sea	2	9,689	38,756
Under rivers	11	6,176	19,465
Underground	14	34,559	1,166,460
Air	15	37,498	1,360,760
Total	42	87,922	2,585,441

Radio

Number of radiotelegraph stations	46

ments required. The plan was submitted by the Minister to the President who approved it.

The first steps already taken to put this plan into effect have consisted in part of completing the copper wire circuits of overloaded principal lines with insufficient capacity to handle the tremendous number of messages being transmitted over them, causing difficulties and delays in the service. Such of these lines whose conductivity permitted a measurable increase in transmission will be equipped with frequency modulation carriers with four telephone channels and a pilot channel, convertible into 18 telegraph channels for every telephone channel or 63 simultaneous communication channels over a single physical circuit with a telephone channel still remaining for voice frequency. The use of multiplex and varioplex systems still would permit a considerable increase in the number of communications over such single lines.

These innovations, aside from the channels used for the transmission of public and official messages, allow other channels to be employed to meet the ever increasing demand for direct communications by the press, financial institutions such as ticker services, and facsimile and telephoto services, as well as for establishing permanent communications requested by large commercial institutions between their main and branch offices.

Once these installations have been completed, it is planned to equip the various main telegraph offices such as those of Mexico; Guadalajara; Veracruz; Tampico; Monterrey; Torreón, Cahuila; Puebla, Puebla; Mérida; and Oaxaca, Oaxaca, with carrier apparatus to enable those central offices to receive and retransmit all telegrams received from other offices in their respective zones as well as to transmit messages to those outlying offices. The carrier equipment installations furthermore will permit the transmission of messages directly from one office to another connected by a different line without the necessity of using intermediate offices or repeaters. However some offices cannot be connected directly that way and must continue to use intermediate offices, but in such instances instead of transmission and reception being executed manually as is being done at present, both operations will be performed automatically through the use of reperforators which will be installed. A double advantage will result from use of this kind of apparatus, for not only will operation speeds be measurably increased, but errors of reception and transmission by hand will be eliminated.

No less important will be the changes planned greatly to improve the national radio network which will include such innovations as the substitution for present equipment of the most modern kinds of apparatus such as single side band types for simultaneous telegraph and telephone communication used principally for international and long distance communications. Other stations will be equipped with modern types of receivers such as diversity receivers with "scramblers." New and larger buildings are to be constructed; still other offices are to be enlarged or changed to other and more suitable locations; and directional sending antennas are to be installed which offer many technical advantages.

The new types of transmitters and receivers which will replace the old ones will permit automatic teletype operation. This is a tremendous improvement over the old types of transmitters and receivers for it permits far greater speed in transmission, greater distance coverage, precision in sending, elimination of interferences, and reliable communication with the help of diversity equipment. Secret communication is made possible by using the scramblers. At the present time radiotelephone communication is limited to Buenos Aires, Argentina, and to some points of Central America, but once the new equipments are installed it will be possible to extend this service by linking up with ground installations, thus permitting telephone subscribers in Mexico, whose telephones are connected with long distance networks, to communicate directly from their homes or offices with any other telephone in the country and also with anyone else in foreign countries through a utilization of these radiotelephone communication circuits.

As both the radiotelegraph and radiotelephone communication systems of the country are under the control of the Ministry of Communications and Public Works, they are used one with the other to provide maximum efficient service.

These new projects, aside from improving telegraph and telephone communications, in the end will constitute a considerable saving for the government. It has been calculated that, because of failure to provide adequate service in many sections and the measurable increase in revenue anticipated once the new equipment is installed, the government will be able to compensate itself fully for the investment proposed of approximately 32,000,000 pesos within about six years. The nation then will benefit further by these installations and their revenue for another approximate 15 years. The telegraph and radiocommunication systems not only will be improved greatly and transmission and reception stepped up tremendously by these new installations, but the public thus will be far better served, the nation then being among those enjoying the best communication systems.

Operating D-C Motors From Controlled Rectifiers

A. SCHMIDT, JR.
MEMBER AIEE

W. P. SMITH

THE D-C output voltage of a typical rectifier has more ripple than the output of a d-c generator. The ripple increases as the number of rectifier phases is decreased. It also increases as the rectifier voltage is reduced by phase control. The voltage ripple affects the performance of d-c motors in a number of respects including heating, commutation, and speed regulation, particularly at light loads and reduced voltage. In recent times the extension of controlled-rectifier drives to d-c motors in the range of 100 horsepower or more has raised the question of modifying the rating of these larger motors when operated from rectifiers with phase control. In order to evaluate the effect of a polyphase rectifier supply on a medium or large sized motor, tests were made on a 400-horsepower 375/750-rpm 230-volt d-c stabilized shunt-wound force-ventilated motor. Tests were made with both 6-phase and 3-phase rectifier supplies, and the results were compared with similar tests using a d-c generator as a source.

To determine the effect of a rectifier supply on the temperature rise of the motor, a number of continuous heat runs were made at various values of load current and armature voltage. At full voltage the 6-phase rectifier power supply did not appreciably affect the temperature rise, but the 3-phase rectifier power supply gave a 10 to 20 per cent increase in temperature rise. At 25 per cent of full voltage, where much greater ripple currents exist, the temperature rise was 10 to 20 per cent greater than normal with a 6-phase rectifier, but was 35 to 120 per cent greater with the 3-phase rectifier. Commutation tests showed that operation from a 6-phase rectifier did not result in poor commutation. The use of a 3-phase rectifier supply impaired the commutation noticeably, particularly at reduced voltage. The results can be seen in Figure 1.

The speed regulation of any d-c motor is the sum of the inherent regulation of the motor and the regulation of its power supply. The voltage regulation of a rectifier is relatively large at light loads and reduced voltage because discontinuous current exists under these conditions. Tests indicate that voltage regulation curves of a rectifier with a motor load can be calculated with good accuracy, provided that the inductance of the load circuit is known.

It should be kept in mind that the unique result of application of a rectifier as a power source for a motor is ripple current, and that the magnitude of this ripple current varies inversely with the motor inductance. The motor used in making the foregoing tests was a medium speed machine without compensating windings and the inductance was, therefore, relatively high. A higher speed motor, or one having compensating windings, may have considerably less inductance. The results of tests on a particular machine must be interpreted with this in mind.

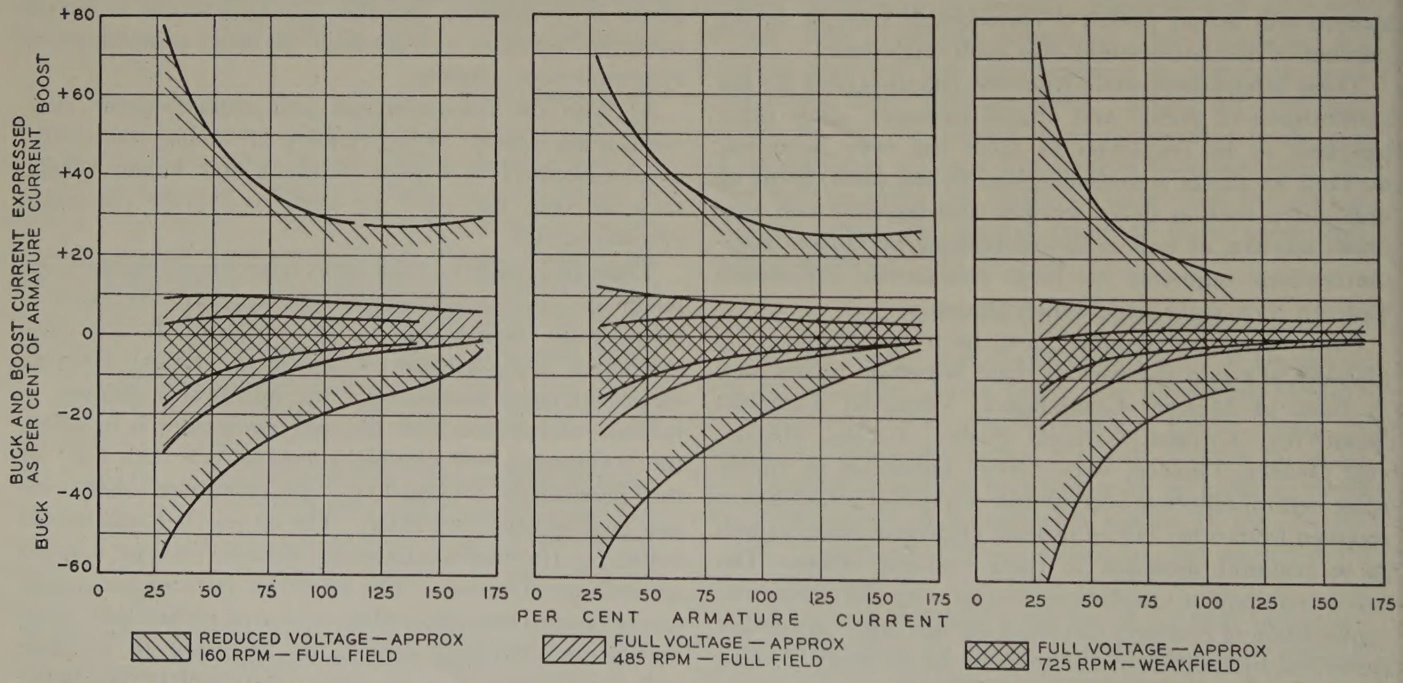


Figure 1. "Black band" commutation curves for a 230-volt 400-horsepower 375/750-rpm d-c motor operating with a generator supply (left), a 6-phase controlled rectifier supply (center), and a 3-phase controlled rectifier supply (right). The area between the curves similarly shaded represents the region of sparkless or "black" commutation and commonly is known as the "black band"

Digest of paper 48-164, "Operation of Large D-C Motors from Controlled Rectifiers," recommended by the AIEE electronic power converter and rotating machinery committees and approved by the AIEE technical program committee for presentation at the North Eastern District meeting, New Haven, Conn., April 28–30, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

A. Schmidt, Jr., and **W. P. Smith** are both with the General Electric Company, Schenectady, N. Y.

Trends in Electron Tube Design

W. C. WHITE
FELLOW AIEE

Electron tube design is an ever-changing and rapidly advancing art. This survey of current practices, developments, and trends gives an over-all view of an expanding electrical industry.

THOMAS Edison, John A. Fleming, Lee DeForest, and the other pioneers in the development of the electron tube found it necessary, of course, to do much design work, but quantity production of many thousands of tubes to meet a specification for use in standardized pieces of equipment appears to have been first encountered by the French in the early part of World War I. When the military communication needs arose at that time and the decision was made to adopt small electron tubes, it was natural for them to turn to the manufacturers of incandescent lamps for production requirements (Figure 1). These lamp makers under the stress of war utilized wherever possible parts and techniques of lamp manufacture. These techniques persisted for many years in tube design and a few features of lamp design still are retained. Many tube manufacturers today are also makers of lamps.

Tube designers and their associates always have been a restless, resourceful group constantly adding new types and forever changing materials, designs, and processes in an effort to expand still further the field of usefulness of tubes, to lower their cost, and to improve their quality as well as performance. This fact must be kept in mind because by the time this article is printed some statements herein already may be out of date.

During the more than 30 years that tubes have been designed on an engineering basis and manufactured in quantity, there have been innumerable changes in tube design. It is not within the scope of this article to trace this history but rather to review briefly a number of the present broad design features of electron tubes and, in particular, to describe trends that designers are thinking and worrying about and thus give clues as to what changes may become increasingly apparent in the next few years.

There are a number of ways in which such a study might be arranged. It seemed best to divide the broad subject of tube design into a number of subdivisions based on certain fields of tube applications. In doing this, however, it must be kept in mind that the term "electron tube" is now a broad descriptive term. Tube size and weight range from a unit that easily could go astray in a vest pocket to one requiring the aid of a crane in moving it about the factory (Figure 2). Also, there is little in common, except the vacuum, between a sealed steel-envelope ignitron and a glass radio-receiving tube. Therefore, from the viewpoint of an engineer specializing in one particular class of electron tube, this article well may be meager in its coverage, but it is hoped that it will give engineers who look at tubes fundamentally as useful tools in electrical engineering a picture of where and how this science is changing and progressing.

GENERAL

In any study of tube design, the enormous continuing expansion of new and different types of tubes and their application must be kept in mind. It cannot be expected that a tube suitable, for instance, for the control of an electric blanket can be used in an intricate computing instrument even if the current and voltage relations are similar. There also will be a growing number of unusual and highly specialized devices utilizing the flow of electrons or positive ions. Examples are the Geiger counter, television camera tubes, electron microscopes, betatrons, and electron diffraction instruments. This article will not even attempt to list all of these special devices but will discuss only trends in the broad classes of tubes which find wide usage. In general, only trends in the Americas will be included. Each of the various fields of application of electron tubes places a different emphasis on the many design factors involved. For some special applications, even a small tube may cost $100 or more and yet its use be highly justified. On the other hand, a tube selling at such a figure, no matter what its capabilities, could not possibly be considered for a home broadcast receiver.

As in any new engineering development, there are differences of engineering opinion on certain aspects of a subject. Time, as usual, will resolve these technical controversies and the various factors will be fitted into their proper place.

Ever since the science of nucleonics has become a common subject of discussion, suggestions have been made that materials giving off alpha, beta, or gamma particles now available after irradiation in an atomic energy pile should find usefulness inside electron tubes. To date no such application

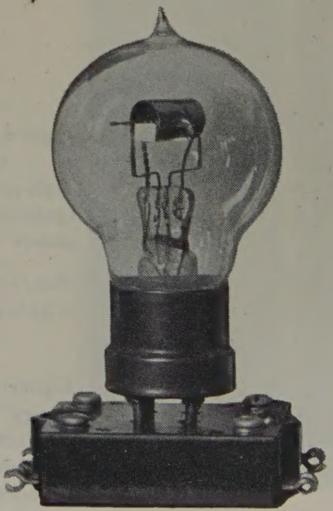


Figure 1. The French World-War-I all-purpose radio tube; manufactured on a production basis in 1916

Full text of paper **48-129,** "Trends in Electron Tube Design," recommended by the AIEE electronics committee and approved by the AIEE technical program committee for presentation at the AIEE summer general meeting, Mexico, Federal District, Mexico, June 21–25, 1948; and scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

W. C. White is with the research laboratory of the General Electric Company, Schenectady, N. Y.

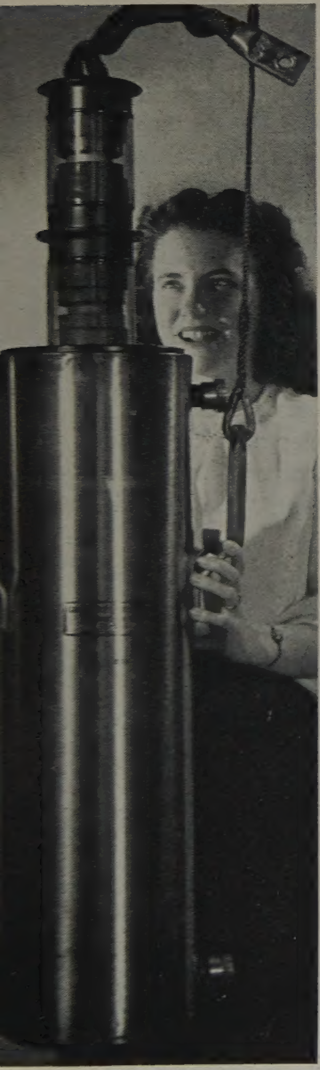
has been disclosed and it would appear that more knowledge and research are necessary before this new science will be directly helpful to the tube engineer.

BROAD TRENDS

In the early construction of electron tubes, all of the electrodes were made of pure metals. The science now has progressed to the point where this is no longer true and in nearly all instances the electrodes have a special surface coating over a base metal in order to provide a maximum usefulness.

Electronics continues to be a science of extremes. Tubes commonly are employed throughout the frequency range between 25 cycles and 30 billion cycles per second. As noted, there are enormous differences in size. Tubes are available that will detect a current of 10^{-16} ampere or deliver a peak current of 10^4 amperes. In a similar way, tubes will respond to potentials of a few microvolts and yet the modern betatron deals with a hundred million volts.

Another interesting feature is that the engineer in no other highly specialized field utilizes regularly so many of the chemical elements including several of the rare ones. More than 30 of the elements commonly are employed by the tube engineer and they span the alphabet from argon to xenon and zirconium.



General Electric Company

Figure 2 (left). A high-voltage high-power sealed ignitron used for power conversion

Rated for 150 amperes at 20-kv inverse voltage

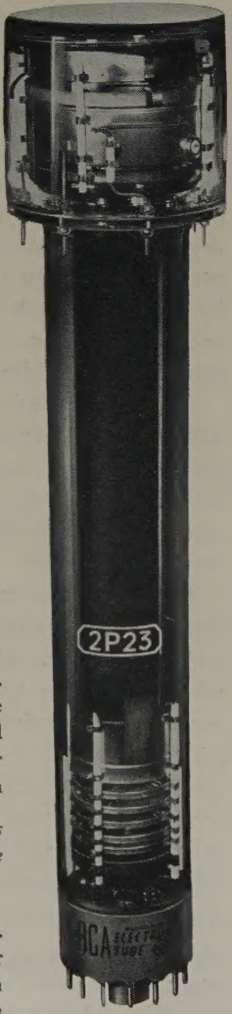


Figure 3 (right). Image multiplier orthicon as used in television cameras for outside pickup

Radio Corporation of America, Victor Division

The frequencies at which tubes are operated are not a factor in their design in the low end of the spectrum of electromagnetic radiations. As the frequency increases, its importance in connection with the design of the tube increases. In the range around 100 megacycles, it has become such an important factor that part of the tube must be considered as part of the circuit. This becomes increasingly true as the frequency is increased still further into the microwave region where the tube structure is often also the circuit.

Another trend apparent during the past few years is that most of the new outstanding advances in electronics have taken advantage of our increasing knowledge of electron beams or what is termed the science of electron optics. Examples of this are the betatron,[1] phasitron,[2] radial beam tubes,[3] cyclophon,[4] traveling-wave tubes,[5] television camera tubes[6] (Figure 3), memory tubes,[7] and others.[8–10] The author believes that this trend will be accelerated and it well may be that almost all of the really new and worth-while advances from now on will be the result of our increased understanding and application of electron optics. Young engineers studying for or just entering the field of electronics, as well as laboratory groups, well might keep this in mind. The number of engineers and physicists with a thorough knowledge of this branch of science plus the other factors needed for successful research and development are entirely inadequate to the possibilities that exist.

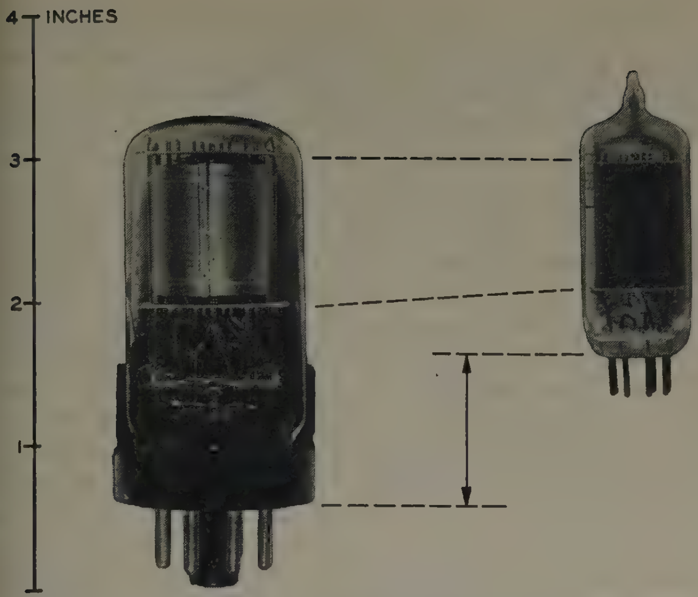
RADIO-RECEIVING TUBES

Miniatures and Subminiatures. Engineers in this field in visiting one another do not delay very long before they are discussing miniatures and subminiatures. From the days of the "peanut" tube of World War I the desire for smaller sizes of tubes has existed but it has taken time to solve the problems of maintaining quality and performance without additional cost. How far the trend towards ever smaller sizes is going is anyone's guess. Press releases from a United States government laboratory of late have described tubes of the "grain of rice" size.[11]

Both the tube and receiver manufacturers have good reasons for wanting smaller tubes. The tube manufacturers see this trend as a basic way toward lower costs because less material is involved and it should be possible to keep the other cost items at about the same or even lower level. Additional advantages are possibilities of speeding up certain manufacturing processes and the minimizing of space requirements for packaged tubes all the way from factory warehousing to the dealers' shelves.

The manufacturers of receivers are working constantly toward a lower cost for their product and smaller tubes mean smaller chassis and cabinet dimensions with accompanying savings in material. In addition there are sales appeal features and fewer problems from microphonics, less breakage in handling and shipment, and better high-frequency performance.

Miniature tubes[12] have been available for nine years or more but originally were designed and utilized almost entirely in battery-operated portable radio receivers and other devices having the same general requirements.



Radio Corporation of America, Victor Division

Figure 4. The miniature tube (at right) has an electrode structure nearly as large as a standard sized tube

The smaller size is accomplished mostly by eliminating unnecessary parts and space

Most miniature tubes are built with tubular bulbs, the trade designation for which bulb is *T* followed by a numeral which is the diameter of the bulb in eighths of an inch. This is not to be confused with the assigned group of designations such as *6T8* and *12AT7* where the *T8* and *T7* have no significance as regards the bulb diameter.

Most receiving tube engineers classify tubes with *T5* to $T6^1/_2$ bulbs as miniatures with a further general understanding that such tubes have basic electrode structures not greatly different in size from similar standard larger tubes (Figure 4). The reduction in dimensions of miniatures is accomplished largely by the elimination of wasted space and unnecessary parts from similar large tube designs. This is indicated in Figure 5 where a modern miniature of a World War II development is shown to be small enough to slip inside the hollow stem of a tube built during World War I. The smaller tube has superior characteristics, however.

Subminiature tubes have diameters below a *T5* bulb and some go down to as small as $T1^1/_2$ bulb (Figures 6 and 7). At present subminiature tubes are used almost exclusively in special applications such as hearing aids, very small portable receivers, and certain military applications where space and weight requirements are extreme. World War II military requirements were powerful influences in the development of subminiature tubes, the best example being the tubes used in vast quantities in connection with the proximity fuse.[13]

Another factor accelerating the trend to smaller dimensions is the use of tubes in relatively large numbers for accomplishing a desired result and, therefore, the space occupied by the tubes becomes important. Examples of this are modern electronic computers which may employ several thousand tubes as well as television receivers having several dozen.

In spite of the size of miniature tubes, the practice of including several electrode structures in one bulb continues. As an example, there is now available inside one miniature-sized bulb the combination of three diodes and a triode.

Some subminiature tubes have flattened bulbs. In general this is believed to be desirable only for some special application such as hearing aids. Most makers of tubes look askance at bulb structures that are not symmetrical around a vertical axis. This is because so much of their automatic manufacturing equipment is predicated on this fundamental geometrical feature.

Miniature tubes are not applicable for all positions in modern radio receivers because the necessary heat dissipation for some design requirements is excessive for these small bulb sizes.

Seven- and 9-pin moulded glass headers are standard for miniature tubes in the industry. For many subminiatures, wire leads are substituted for pins.

Miscellaneous. For applications in battery-operated equipment, filament power is reduced to 50 milliamperes or less from a $1^1/_2$-volt dry cell. For some special uses, tubes having even lower filament currents are available.

In radio receivers, pentodes still are used generally for radio-frequency and superheterodyne intermediate-frequency amplifiers and pentagrid tubes are employed almost universally as converters.

There are now about 500 types of receiving tubes listed and of these more than 50 are miniatures. There seems to be no question but that the number of types is going to increase at an accelerated pace because of the requirements and developments in television and frequency-modulation broadcasting, as well as other special uses.

The demand for higher values of transconductance, which has confronted the tube designer from the beginning, continues, and associated with it is the accompanying need for lower output impedance values in order to give more uniform response over a broad-band of frequency. As a result, the tube designer has been forced to much closer interelectrode spacings, particularly between cathode and grid where three mils or even less is now common.

As has been indicated, standard sized tubes still are used for some functions in receivers where the heat dissipation is too high for the smaller sized bulbs of the miniature tubes. Examples of this are rectifier tubes for large receivers and tubes for deflection of the beam in picture tubes as well as for certain audio amplifier circuits.

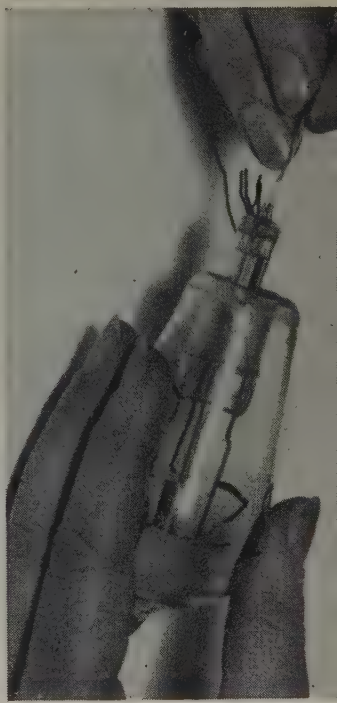


Figure 5. A World War II tube slips easily inside the stem of one built during World War I, yet the smaller one shows better performance

In many standard sized receiving types, the steel envelope design continues in common use. New designs of receiving tubes are relatively infrequent in the large standard size, so probably there will be few new designs of the large metal tubes in the near future.

Some Manufacturing Features. The use of coated filaments applied in the form of the carbonates of the alkaline earth metals is almost universal.

Grid wires commonly employ molybdenum or its alloys. Such wires are used in diameters as low as one to two mils. The minimizing of primary emission from the grids usually is accomplished by some special surface treatment, each manufacturer having his own favorite technique.

The anodes are mostly of iron or steel with some surface treatment. A new material, proposed for this use, is aluminum-coated steel. This is built into the tube as a bright surfaced metal but upon being raised to a bright red heat during evacuation of the tube, it suddenly changes to a dark gray color. This is a very useful characteristic as it permits the freeing of the anode metal from gas with reasonable amounts of heating power because of the poor radiation of a shiny surface. In the finished tube, however, it provides a dark and thus high heat radiating surface permitting lower anode temperatures. The basic idea seems to have come from the Germans and is one of the two worth-while new ideas that were initiated in enemy countries during World War II. The other is ceramic material suitable for tube seals and envelopes. Although this latter is an important new development on which tube engineers are very active in the United States, as mentioned elsewhere, it is not being applied as yet to receiving tubes.

Barium-content getters are employed almost universally. Zirconium, although in fairly common use for transmitting tubes, is not being applied commercially to receiving tube production.

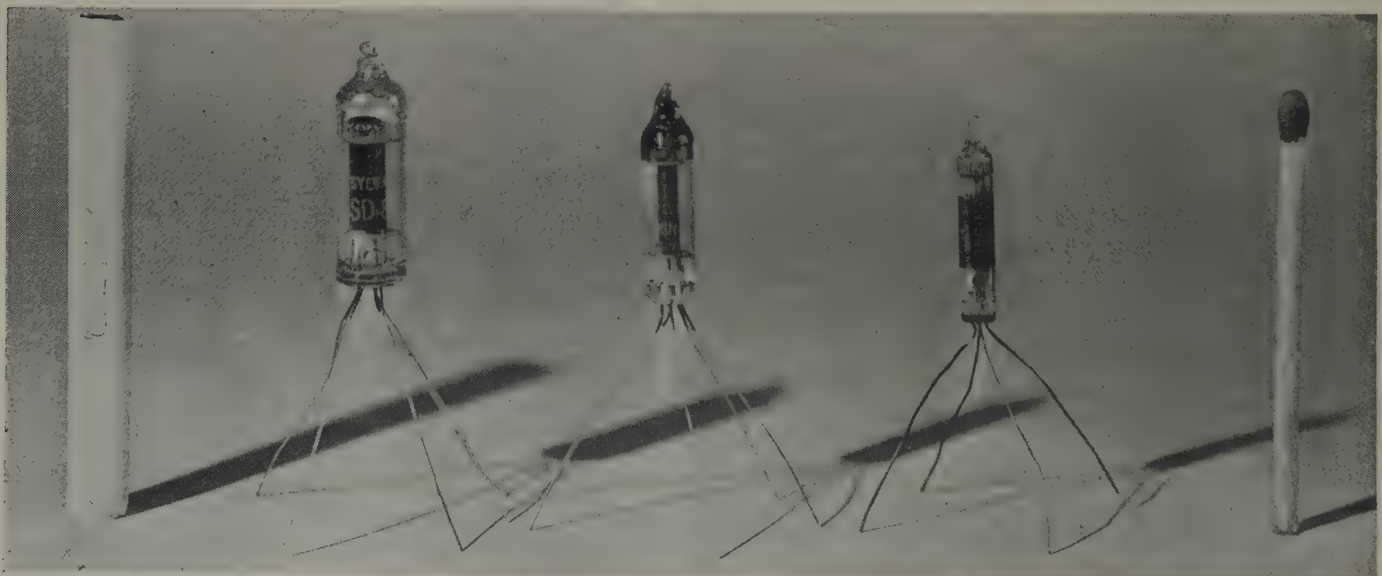
Most receiving tubes are designed for operation of the cathodes at 6.3 or 12.6 volts although there are many other voltages utilized for special cases. Tubes designed for 110-volt heater operation would be welcomed by many receiver designers but several difficult problems are involved and this feature is not particularly favored by tube engineers and, except in very special instances, probably will not be used to any great extent.

Most radio receiving tubes are operated at plate voltages under 150 and a common maximum rating is about 300.

Ever-Present Problems. The tube designer is confronted constantly with the problem of cutting tenths or even one-hundredths of a cent out of the cost of a tube. This is accomplished either by redesign or lower manufacturing losses. The mechanization of tube manufacture is an important phase of cost reduction. It is going on actively step-by-step in all the operations involved. Complete machine assembly of tubes on a commercial basis still appears to be a future development.

Two other problems confronting tube engineers is the minimizing of grid emission and the decrease and control of electric leakage between the heater and the cathode in tubes utilizing these features. The latter problem is a most difficult one because of the problem of designing a hollow red-hot metallic conductor about the diameter of the lead in a pencil into which is put another red-hot conductor with only two mils available for space in which to place insulating material, the whole having to operate in the reducing action of a high vacuum. This combination not only must be operated at 110 volts between the two elements without breakdown, but the leakage resistance between the two must be above about 100 megohms per inch of conductor. Admittedly, this is quite a problem, particularly in devices which must be manufactured for a fraction of a dollar each in million lots. Tube designers are meeting this very difficult requirement by the use of alumina. Many close manufacturing controls are involved, however.

As discussed elsewhere, there is a constant urge to minimize early life failures and this can be done only by careful attention to scores of design, process, and material details.



Sylvania Electric Products, Inc.

Figure 6. Sizes of subminiature tubes compared with a standard length cigarette and kitchen match

Conservative operation is recommended to minimize early ailure and in some instances to obtain long average life.

Another favorite topic for discussion is when or when not to create a new type of tube to meet the real or fancied demand of someone with a new circuit or application.

New Problems. The tubes available for radio receiver designs are suitable in general for frequencies up to 216 megacycles, which is the top limit for present commercial television. However, tubes for the citizens' radio band (460–470 megacycles) and the wide frequency zone extending up to nearly 1,000 megacycles that has been set aside for color and other improved television systems presents a whole new series of problems. For these higher frequencies, some of the special tubes, such as klystrons, disk-seal tubes, dyotrons, to be described later, well may enter the picture.

Future Problems. In discussing the future with men in the industry, several subjects usually are introduced. One s a need for a special tube for frequency modulation receivers to combine the functions of discriminator and limiter and possibly include other useful characteristics. As one engineer expressed it: "We know that someone s going to pull such a tube out of the hat, but we don't know from whose hat it is coming."

Although ceramics are not employed today in standard receiving tubes, this technique is being thought about as one possible way of building miniature tubes that will dissipate more power. There are reports that such tubes have been built in Germany and are operated at a temperature of several hundred degrees.

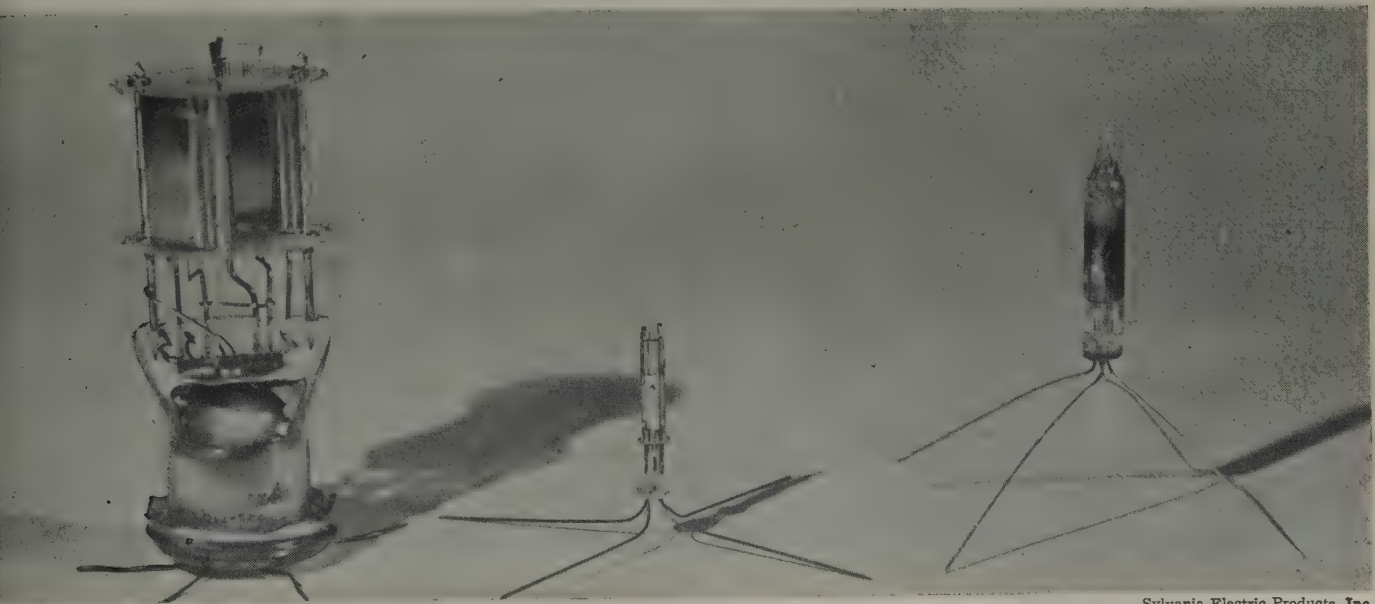
There is also some speculation on the substitution of tubes soldered into their circuits rather than utilizing bases and sockets. There are a number of factors favorable to such a future development. Some of these are the new printed circuits and the wire leads on subminiature tubes. There is also the fact that there is less tinkering nowadays with radio receivers in the home either by amateurs or professionals. The diagnosis and repair of faults in a modern radio receiver can best, and sometimes only, be accomplished in a well-equipped radio service shop. The advent of television receivers emphasizes this trend. It is also no easy matter for the designer of a television receiver to arrange for chassis units in which every one of the two dozen or more tubes can be removed and replaced easily even with bases and sockets.

SMALL RECEIVING TYPE TUBES FOR INDUSTRIAL CONTROL AND INSTRUMENTATION

For many years this field of application was supplied by using standard radio receiving tubes. In order to obtain from them the greater uniformity and longer tube life needed, it was customary to operate the tubes very conservatively as regards plate voltage, plate current, and often cathode temperature. It also was believed that the low cost of receiving tubes and their almost universal availability were strong reasons for following this policy.

Of late, however, opinions on this subject have been changing. This is attributable to a number of factors:

1. Even under favorable conditions, the life is often too short for use continuously 24 hours per day. Industrial users of tubes now talk about the life in years rather than in a few thousand hours and the elimination of early failures is of increasing importance.
2. Mechanically, some users (often mistakenly) believe that radio receiving tubes are not strong enough for their applications. They need not have the extreme sturdiness of the tubes used in proximity fuses[14] which actually were shot out of a gun, but they may incorporate to advantage some special mechanical design features for some of the new services.
3. Users of tubes for instrumentation in particular have been critical of the wide variation of electron currents and other characteristics between individual tubes.
4. Many tubes have not been considered satisfactory as regards constancy of anode current during life.
5. The great increase in the extent and variation in industrial use has created new requirements.



Sylvania Electric Products, Inc.

Figure 7. Comparison between *T-1* and *ST-12* types for size and simplicity of design

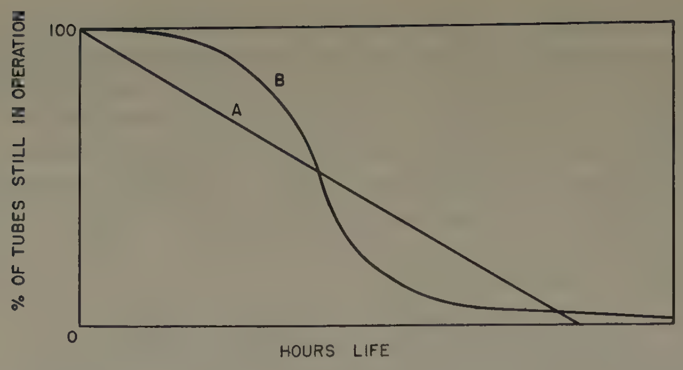


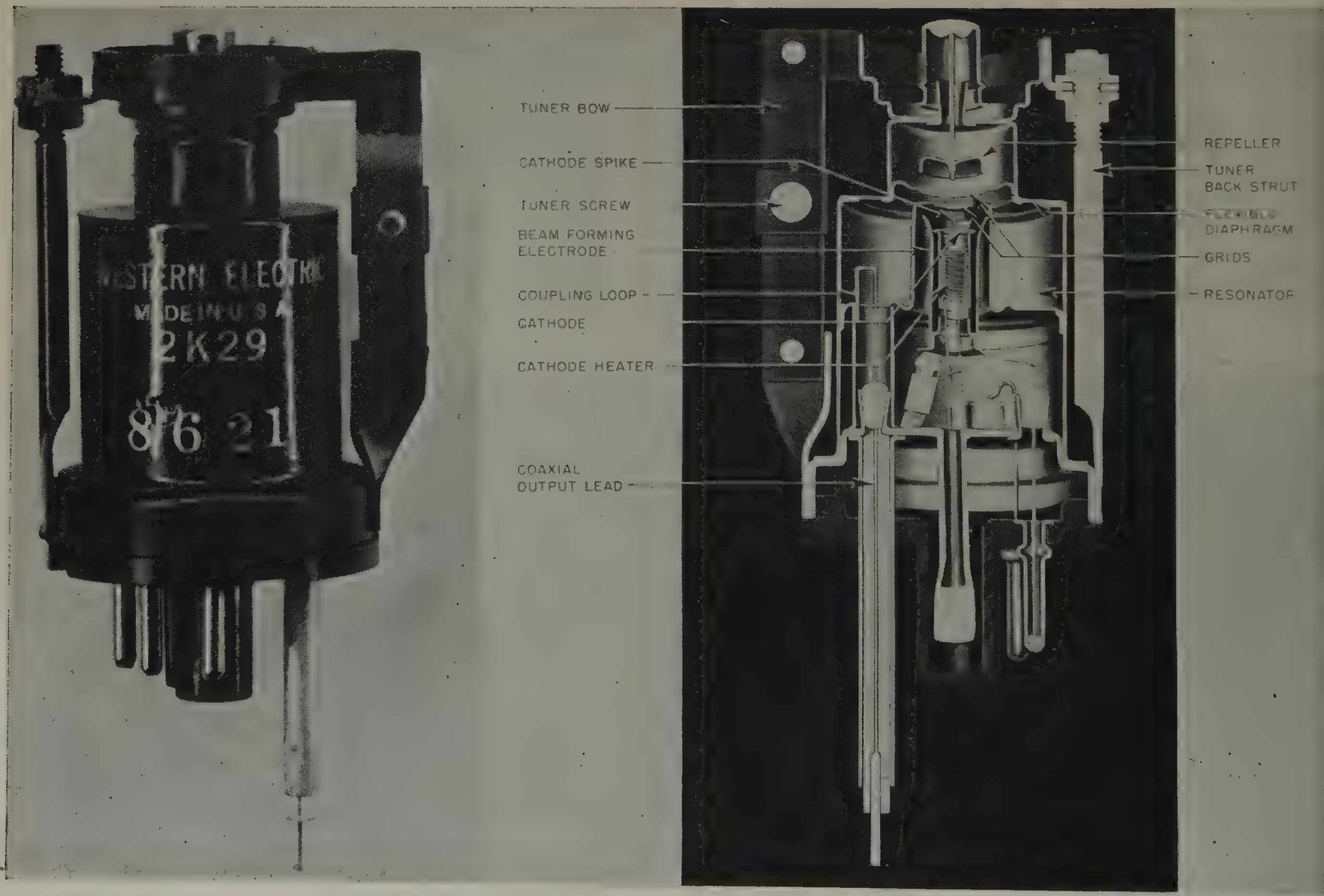
Figure 8. The mortality curve of vacuum tubes assumes a shape shown in *B* as design and quality are improved

6. From time to time a tube manufacturer has changed some electrical or mechanical design feature which has been unimportant from the viewpoint of radio receiver use but has introduced serious difficulties in certain industrial applications. Therefore, revised and more definite specifications may be looked for in the future.

A good example of this last factor was a time delay relay, the coil of which was operated from the plate current of a receiving-type tube. The current and voltage requirements were very low and, as very long life was desired the tubes were operated at subnormal cathode temperature. Satisfactory results were obtained with renewal tubes for a number of years but during the war apparently ne cathode materials were substituted or a process chang so that, while the electron emission was normal at rat heater voltage, it was entirely inadequate at the lowe heater temperature used in this industrial applicatio Therefore, renewal tubes of the later date of manufactu were inoperable in the equipment in question.

One manufacturer has announced a new line of sma industrial tubes to replace similar radio receiving tube Initially there are three types in this line (not miniatures Two of these are of glass and one has a metal envelop These three new tubes are in general mechanically an electrically interchangeable with corresponding radi receiving tubes. They, of course, have different designations and incorporate improvements over their radi counterparts as to life, uniformity, constancy of chara teristic during life, and mechanical strength. This featu will allow users of these tubes in industrial equipment decide the merits of such specialized designs for their ow particular devices and operating conditions. The use this specialized line of tubes for industrial applications described will be watched with great interest both b the tube makers and manufacturers of industrial electroni equipment.

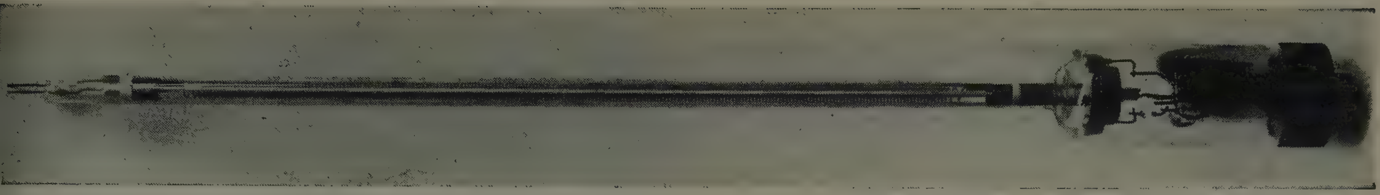
That this general subject is an important one and considerable interest to the members of the Institut



Bell Telephone Laboratories, In

Figure 9. Microwave reflex oscillator tube

This general design is suitable for frequencies up to 10,000 megacycles



Bell Telephone Laboratories, Inc.

Figure 10. Traveling-wave tube having high gain and very broad band characteristics in the 4,000-megacycle region

is evidenced by the fact that the AIEE joint subcommittee on electronic instruments prepared a questionnaire on the subject of tubes in this field and in response obtained a wealth of information. This was summarized, presented, and discussed at a 2-day meeting sponsored by this committee in Philadelphia during March 1948.

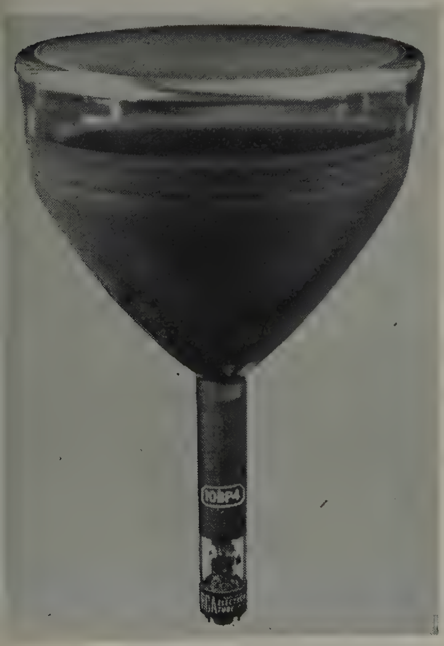
Tube Life. Of all the tube characteristics of interest to industrial users, life[14] is probably the most important. There are a number of features in connection with tube life that are of interest.

If the operating life of a tube were dependent on a pure random phenomenon, then a plot between the percentage of the tubes still operating and hours of operation would look like curve *A* in Figure 8. In such a case, taking a tube out of service, for instance, at 1,000 hours and substituting a new one as a method to insure continuity of operation is illogical. The reason, of course, is that at the end of 1,000 hours any given tube is as likely to operate another 1,000 hours as a renewal tube is to operate its first, 1,000 hours.

When the life of a tube is based on some definite physical effect, such as evaporation and burnout of a pure tungsten filament, then the life expectancy curve tends to assume a shape, such as shown in curve *B*, Figure 8. The more definitely the end of life is associated with a single definite variable and the better the manufacturing control in the making of the tube, the more pronounced will be the shape of this curve.

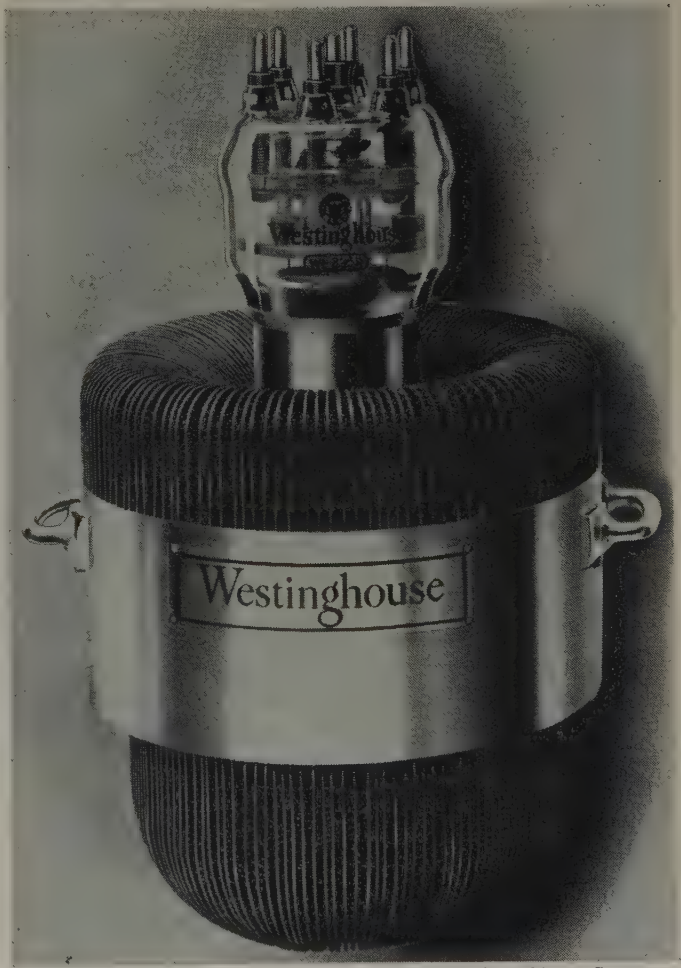
The upper left portion of these curves is the important region. This is due to the fact that prematurely early failures are particularly troublesome to the users and, therefore, considered undesirable by tube manufacturers. To a large extent these early failures are due to accidents rather than to any basic factor controlling life. The average life of many modern radio receiving tubes, however, is satisfactory for some industrial uses.

There appear to be two ways of meeting this situation and both are being employed. The first is the introduction of continual improvements in manufacturing control and testing so as to eliminate before shipment the tubes that will show early failure. The second method is to provide increased design life and further insure longer life by conservative operation and provide improved conditions of



Radio Corporation of America, Victor Division

Figure 11. A television picture tube with a 10-inch diameter face



Westinghouse Electric Corporation

Figure 12. A high-power transmitting tube for radiobroadcasting

This air-cooled unit will dissipate 20 kw and weighs more than 200 pounds voltage constancy and a minimum of off–on interruptions. By this method the abscissa scale of Figure 8 is extended to such an extent that the critical right upper portion of the curve tends to become flatter for any definite number of hours.

SMALL TUBES FOR THE TELEPHONE SYSTEM

Many of the engineering requirements fundamental in this application of electron tubes are quite different from those of radiobroadcasting. For the most part, the tubes are of low power and superficially many appear to be similar to radio receiving tubes although they differ to a marked extent in ability to meet certain basic requirements.

The frequency range of tubes is just as extreme as in radiobroadcasting, running all the way from 60-cycle low-power rectifiers[15] to 4,000-megacycle or more tubes as used for microwave relaying stations.[16]

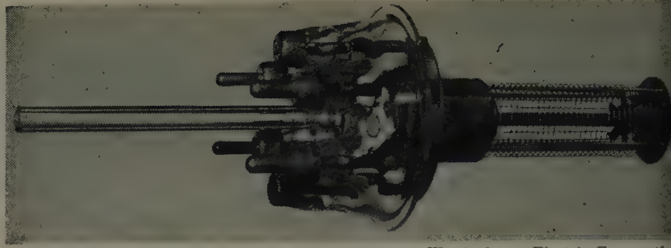
In the voice and carrier frequency field, uniformity of characteristic, constancy of performance during life, and a long average life free from early failures are all important requirements. Transcontinental lines, particularly if carrier is involved, require a simultaneous use of many hundreds of tubes. This emphasizes the need for life reliability in each individual tube. To gain this end, a long-life design is the first requirement; and this is supplemented by continuous operation and carefully controlled operating conditions such as constancy of cathode heater voltage. In such applications it is also customary to check the tube performance periodically and eliminate tubes in which a slight falling-off of performance is noted. It is sound economically in the telephone system to employ a higher cost for certain tubes in order to obtain better performance and life because of the economies effected elsewhere in the system.

Miniature tubes are of interest for mobile equipment, in satellite installations where the complete equipment is mounted in a small case, sometimes on a pole installation, and where the power supply of filament and plate may be supplied over the incoming lines.

There is not a great deal of interest in steel-envelope tubes except for special cases where the metal envelope of itself is highly desirable. A good example is the single-cavity reflex oscillator tube. A movable metal diaphragm for tuning is a necessary part of the design (Figure 9).[17]

For certain types of equipment, it has been found advantageous to mount the tubes permanently into a chassis and substitute soldered connections to the tube terminals for the usual base and socket arrangement. The completed assembly is treated as a packaged unit, removable as a whole, for inspection, maintenance or repair. A "permanent" tube designed to be incorporated inside of a cable has been reported and in such cases, of course, the tube life must match the estimated useful life of the cable.

At the present time there is much interest in tubes for use in the 4,000-megacycle region which has been assigned by the Federal Communications Commission for microwave beam relaying. The velocity-modulation type of tube, of which the klystron is an example, now is used in the Boston–New York microwave relay link. Showing



Westinghouse Electric Corporatio

Figure 13. Moulded glass terminal header for a high-power tub

promise for future installations is the traveling-wave tub (Figure 10) because of its high gain and broad-band characteristics, and the disk-seal triode for its low nois and satisfactory broad-band features. In the highl refined designs of these special microwave tubes, clos cathode to grid spacings, fine grid wire diameters, and smooth surface for the electrode structures are carried t extreme values.

In small thyratrons, there is not the marked trend toward gas filling evident in the industrial field. Iner gas filling is used frequently but only as an addition t and not as a substitute for mercury vapor. This is logical combination because extreme temperature varia tions are not often encountered in this field, the anod voltages are low and the tubes run almost continuously.

TELEVISION PICTURE TUBES

Until recently engineers in this field were most active o the development of projection-type tubes so as to provid larger pictures than those obtainable directly on the fac of the tube. Although there is still activity on this subject it is not in general occupying as prominent a part i development programs as it did a year ago. This probabl results from the fact that television commercially seems t have finally "turned the corner." Therefore, all possibl effort is being placed on lowering the cost and improvin the performance of direct view cathode-ray tubes fo television reception. Projection tubes as now used give a picture none too favorable as regards sharpness and brilliancy when compared with the most modern larger direct view tubes.

There seems to be a growing opinion that until the resolution of the picture is improved increasing its size is only beneficial when it is viewed from a greater distance and is, therefore, chiefly applicable to larger groups of people than gather in the average home.

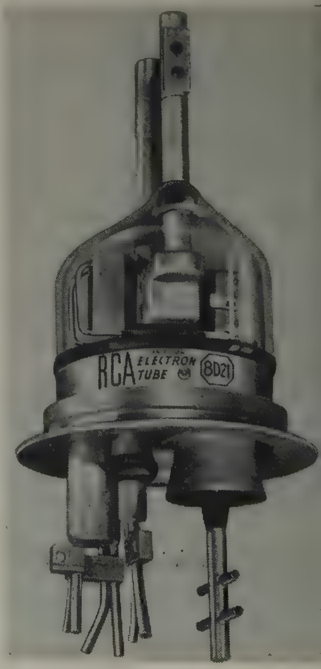


Figure 14. A twin power tetrode for inputs up to 10 kw and for frequencies up to 300 megacycles

Radio Corporaton of America, Victor Divisio

The opinion also is expressed that the projection tube is not now the key factor in the problem of larger pictures by projection. The real problem appears to be a satisfactory low cost optical system to supplement the tube.

Of considerable interest in the industry today is a discussion of two active developments, namely, the matter of aluminum-backed screens and ion traps. Many factors are involved. The aluminum-backed screen, the newer feature of these two, has a deposit of a very thin aluminum on top of the fluorescent material in the bulb interior. The proponents for this development are enthusiastic about the brighter image obtained, the improved contrast and definition of the picture, and the prevention of the formation of the troublesome ion spot.

The ion trap is a tube design feature aimed to solve in a practical way the problem of the ion spot. This ion spot is a circular spot or area of darkening discoloration on the face of the tube that slowly and increasingly shows up during tube life. It has been found to be caused by the negative ions produced from the electron beam. The ion trap is an ingenious arrangement by which a magnetic field is made to deflect the negative ions into a different path than the electrons on somewhat the same principle as employed in the mass spectrometer. Advocates of the ion trap believe that it is the surest way of eliminating this troublesome effect and at the same time give the lowest tube cost for a satisfactory picture.

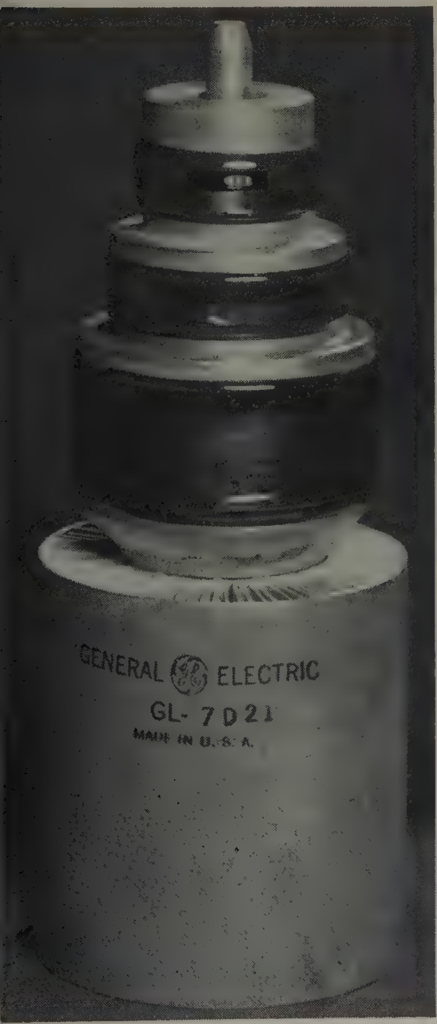
The life of direct view cathode-ray tubes as used in television in general has been very satisfactory as is the color of the phosphor and its persistence. Unlike the field of radio receiving tubes, there probably will not be as large or as rapidly growing number of types of picture tubes at least as regards the bulb dimensions. This is because to obtain low-cost bulbs the manufacturer must expend very large sums in tooling up for their production.

There is a thorough standardization system similar to receiving tubes set up among manufacturers as regards interchangeability on a given type designation. The present standard enjoying the largest production is a 10-inch diameter tube. However, there appears to be a trend to 12-inch tubes and possibly larger ones if they can be produced at only slightly higher cost than the 10-inch size (Figure 11). Tubes having a face diameter of 20 inches are now commercially available. The matter of rectangular faced bulbs is receiving some consideration for production.

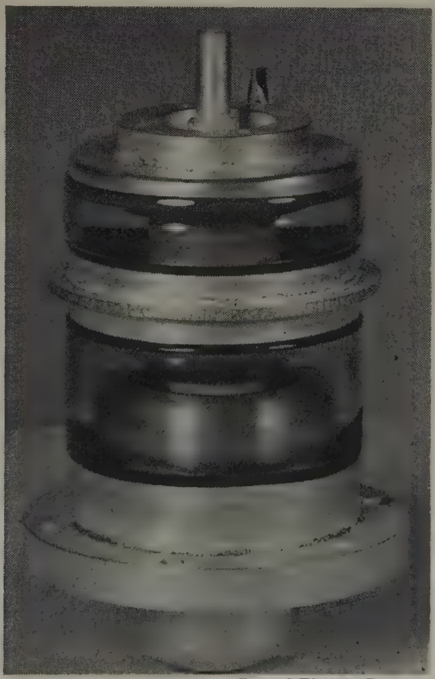
The beam in a cathode-ray tube may be focussed either by a magnetic or an electric field. The same is true of the deflection of the beam. Many factors are involved in the choice made of these methods. Today the majority of the present standard 10-inch picture tubes use a magnetic field for each function.

During the past few years there has been an improvement in the appearance of the television picture as a result of the flattening of the face of the bulb. This trend seems to have reached a certain degree of stability using a bulb face with a relatively large curvature rather than a real flat surface.

The television receiver designers, of course, would like shorter cathode-ray tubes to aid them in building smaller, lower cost cabinet designs. Today, however, there is no apparent way of accomplishing this to a marked extent without introducing other features that are disadvantageous and tend to offset the gain of shortened length.



General Electric Company



General Electric Company

Figure 15 (left). Forced air-cooled tetrode, incorporating seals and terminals

For outputs up to 1.5 kw at 110 megacycles. Designed for grounded-grid circuits

Figure 16 (above). Water and forced air-cooled triode for outputs up to 6.4 kw at 200 megacycles; designed for grounded-grid circuits

TRANSMITTING TUBES

General. Unlike radio receiving tubes which, as a class, are highly standardized through the agency of the Radio Manufacturers Association, there is little such standardization in the field of radio transmitting tubes. In general, each make of transmitter requires the use of tubes specifically designed for it by one particular manufacturer. This probably makes obsolescence and development a more rapid process but, from the viewpoint of a user or purchaser of the equipment, it would appear to have some disadvantages. Type number designations, however, are assigned by a joint agency of The National Electrical Manufacturers Association and the Radio Manufacturers Association. Formerly the system was a combination of numerals and letters, such as *9C24*, but the newer procedure on other than receiving and cathode-ray tubes is the assignment of a 4-number designation, such as *5518*, in which the numbers have no significance as regards the size or characteristics of the tube. The custom of prefixing the type number by a manufacturer's letter identification continues.

One general trend in new designs is the increasing use of thoriated filaments[18] (except in the case of magnetrons) relative to pure tungsten and coated filaments. The so-called thoria-coated filaments, as distinct from thoriated filaments, are in limited use but it is doubtful whether this type of cathode will become commonplace.

Another general trend is toward forced air cooling for larger and larger sizes of tubes (Figure 12). Per kilowatt of output, an air-cooled tube is more costly than a water-cooled tube, but the manufacturers and users of radio transmitting equipment, particularly in the broadcasting field, greatly prefer air-cooled tubes.

Probably one of the most active, forward-looking laboratory developments not yet in production is the use of ceramics[19] for seals and terminal insulators to replace glass. This new material is of great interest because certain compositions have very low dielectric loss for the high frequencies at high temperatures. It also can operate at much higher temperatures than glass without softening or being subject to electrolysis. Another advantage is that it provides opportunities for new assembly procedures. As mentioned previously, this development is one of the two main contributions from enemy countries during World War II. In the development of ceramics, the idea that they could be used for this purpose is the chief contribution as the materials we are using in the United States and the methods of sealing them to other parts of the tube structure are being developed along very different lines than in Germany.

Some General Problems in this Field. When asked about ever-present problems, one engineer expressed it rather aptly by saying that one of the most troublesome ones was "getting more emission where you want it and less where you don't want it." In other words, more emission, particularly per unit of area, is constantly desired for cathodes and at the same time grid emission must be minimized.

The designers of transmitting tubes also are being reminded constantly that designs are needed for ever-higher frequencies and once such a design has been produced then the demand is for ever-larger and larger power ratings.

From the structural viewpoint, there is a constant urge toward closer interelectrode spacings and finer grids in triodes and tetrodes. This urge, of course, comes from the need for higher values of transconductance at low output impedance to get improved broad-band operation, particularly in frequency modulation and television.

One noticeable design feature in many of the newer tubes is the localized cooling of both filament and grid leads as well as certain areas of glass bulbs or seals subject to local heating. This is accomplished by sharply directed air streams as well as water circulated through cooling ducts. The need for such cooling well might be eliminated by the use of ceramic materials.

Some Materials and Techniques. In large glass transmitting tubes, nearly all of the newer designs utilize moulded glass headers, the terminal pins all extending through this header (Figure 13). More recently, and particularly for the shorter wave lengths, the glass header is being replaced by one of metal and bushing-type seals or their equivalent are being introduced (Figure 14). Thus in one way or another, there is a tendency toward eliminating glass, in so far as possible, in all tubes for very high power, particularly those for the shorter wave lengths.

In all except the smaller sizes of tubes, seals utilizing large wires through a pinched-off stem are being replaced by disks, cups, or cylinders of alloy metals.

The metal zirconium is being used to an increasing extent as a coating on hot radiation-cooled electrode surfaces. It acts as a getter and also forms a surface having greater heat radiating properties than a shiny metal. It is employed on a number of different base metals. For new designs having radiation-cooled anodes, graphite and pure tantalum do not seem to be employed as extensively as a few years ago.

For the ever-present grid emission problem, several methods are being worked on intensively; but covering the surface with some form of platinum seems to be a favorite method.

Classification by Frequency. A convenient way to cover the subject of transmitting tubes is to group them into several classes based on broad frequency ranges:

1. Broadcast frequencies up to several megacycles.
2. Frequencies used in frequency modulation and television transmitters. This now extends up to 216 megacycles.
3. Frequencies from the foregoing value up to about 1,000 megacycles. This includes the so-called citizens' band and the very large number of channels set aside for improved television utilizing either high definition or color or both.
4. Frequencies above 1,000 megacycles, commonly designated as microwaves.

Present Broadcast Range. There is not a great deal of activity in this field, particularly in the smaller sizes of tubes where requirements are pretty well taken care of by present designs. War stock surpluses are also a factor.

The feature of utilizing 2- or 3-phase filaments to minimize hum, which was common a few years ago, is not appearing in the newer designs. This is caused partly by better hum compensation or balancing methods, as well as by the fact that the problem is less acute because of the lower currents utilized in thoriated filaments.

Frequency Modulation and Television. Thi field is very active in requiring new designs (Figure 14) up to those large enough for a station rated at 50-kw output. One of the chief problems confronting the engineer in this field is that of obtaining more electron emission per unit area of the cathode. This factor has been improved more than tenfold during the past few years but the urge to improve it still further continues.

Many of the new types incorporate disk or ring-seal features for a grid terminal and are designed for use in grounded-grid circuits (Figures 15 and 16).

As has been noted, forced air cooling is favored by the users of broadcast transmitting tubes. In the past not too much attention has been given to the aerodynamics involved but this factor probably will be studied more thoroughly and marked improvements made in the newer designs.

The power gain per stage is an important factor but is tied up in a rather complicated way with several other factors.

Some engineers feel that magnetron developments may affect to a marked extent future activities in transmitting tubes for these frequencies. If such magnetrons can be designed with satisfactory output and efficiency and capable of modulation with low power, such a combination well may change the tube design picture. This is particularly true if the result is suitable for both frequency or amplitude modulation. Considerable research work in this field is going on.

Frequencies Up to 1,000 Megacycles. There is not much activity in developing special tubes for the so-called "citizens' radio band" (460–470 megacycles). There seems to be a general feeling that this application might find satisfactory use on a small scale but in mass quantity use there are many difficulties. This has resulted in a "let's wait and see" attitude. There are tubes available for this application that will take care of present developments although that is hardly true for light portable transmitting equipment.

For the broad band of frequencies between 480 and 920 megacycles assigned to television developments, there is also considerable activity but the situation is similar to that in the present television band. In other words, triodes and tetrodes utilizing certain features of disk-seal tubes are applicable in some cases (Figure 17) although the types of tubes suitable for the next higher range of frequencies are not being forgotten.

Ultrahigh-Frequency Tubes. At the present time, except for high-frequency heating, most of the applications, actual and proposed, are in the field of communication. The power ratings of such tubes are also relatively low although this is more a matter of inability to make high-power tubes except as oscillators.

There are a number of varieties of tube types which are useful in this frequency range. It is too early for a clear or final analysis indicating the position of each type and to where and what extent each will be used. The following comments seem to cover present engineering opinions.

Magnetrons.[20] These tubes are primarily oscillators not usable as amplifiers but are particularly suitable where high peak powers are required, such as radar. They are suitable also for generating continuous output high frequency and, as has been indicated, well might fit in the frequency modulation and television picture if satisfactory means of modulation can be developed. They appear also to have a very promising future in high-frequency heating at about 1,000 megacycles or more (Figure 18).

Velocity Modulation Tubes.[21] These tubes also are designated as velocity variation tubes and klystrons (Figure 19). They are useful as oscillators and amplifiers and lend themselves very readily to frequency modulation. They have proved to be exceedingly useful as signal generators and as power oscillators within the range of their ratings. The chief disadvantages are their relatively narrow bandwidth as amplifiers, low efficiency, and relatively high level of inherent noise that limits their use as receiver amplifiers.

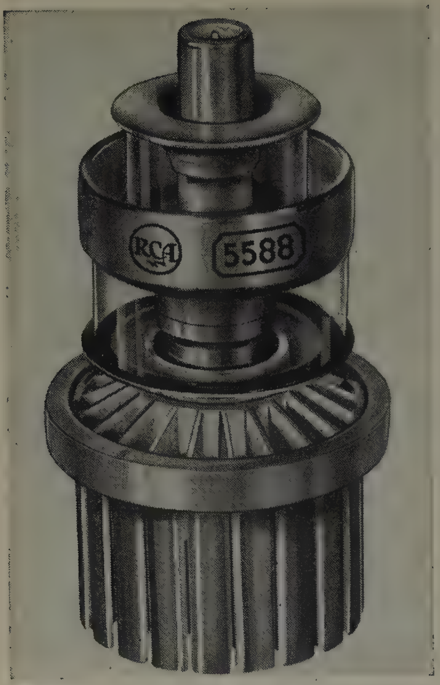
Traveling-Wave Tubes.[5] These tubes (Figure 10) have extraordinary capabilities as to high gain in combination with an exceedingly broad band for amplification. They appear to be subject to somewhat the same limitations as to noise found in connection with klystron tubes. This tube is a relatively new development and accurate appraisal is not yet possible.

Disk-Seal Triodes and Tetrodes.[22] These now are limited in frequency to about 4,000 megacycles and have relatively low gains as amplifiers. Control of frequency and possibilities of satisfactory modulation are not considered as good as in the klystron. Their outstanding advantage is their low signal-to-noise ratio making them suitable for low signal level amplification. Their capabilities as broadband amplifiers are not as outstanding as the traveling-wave tube but are apparently sufficient for many applications.

Dyotrons. These tubes are structurally similar to a triode but operate with a moderately noncritical transit angle and require a radio-frequency short circuit between cathode and grid. As the grid and cathode have no radio-frequency potential difference, only one tuned circuit is required. They are the newest of the special types listed and very little information is yet available. They would appear to be particularly promising in fields that now are served by the klystron and disk-seal types.

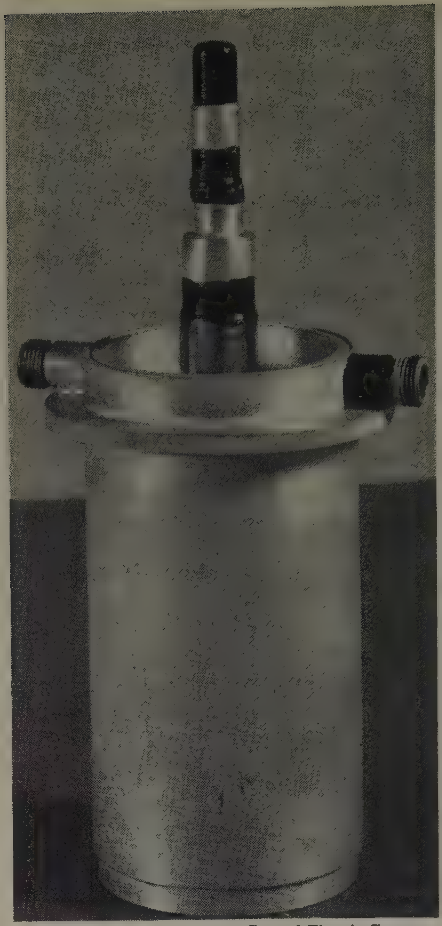
THYRATRONS AND IGNITRONS FOR INDUSTRIAL CONTROL

Thyratrons. Here the most pronounced trend is the increased use of an inert gas filling in place of mercury vapor. The object of this change is to make the operation of the tube and its characteristics independent of ambient temperature over a very wide range. The variation of operation with temperature often presents difficulty in the application of mercury-vapor tubes resulting from the great change in vapor pressure with change in temperature of the mercury. Indirectly the elimination of the mercury vapor helps to shorten the warming-up time. This independence of ambient temperature is also very helpful in fitting in with the modern trend toward totally enclosing industrial control equipment in steel cabinets. The inert gas used is pretty generally xenon. The real problem in this substitution of an inert gas has been to prevent the "clean-up" of the gas which resulted in short life. The attack on this problem has been along two lines, the first involving circuit arrangements[23] to lower



Radio Corporation of America, Victor Division

Figure 17. **Small transmitting tube with ring-type grid terminal, suitable for use in a grounded-grid circuit up to 1,200 megacycles (length about $3^1/_2$ inches)**



General Electric Company

Figure 18 (right). **A 5-kw water-cooled magnetron for high-frequency heating at 915 megacycles (length about $9^1/_2$ inches)**

the rate of change of inverse anode voltage on the tubes. The second improvement lies in the design and processing of the tubes themselves.[24]

Much progress has been made in both these directions. The circuit in which the tube is used is still a factor but less vital than it was a year or two ago. Tube designers are quite confident that in the not too distant future they will be able to build gas-filled tubes giving an entirely satisfactory life under almost all required circuit conditions within the rating of the tube.

As a part of this program of improved tube design, the deionization time[25] has been decreased. This also permits tubes of the new design to be used at frequencies higher than 60 cycles. This is a favorable condition toward possible general application on the 400-cycle power supplies now used in some aircraft and for other special conditions.[26]

Thyratrons are now available in miniature dimensions for control and instrumentation applications where the average current requirement is in the milliampere range.

Quick heating of the cathodes (one minute or less) is considered a very desirable characteristic by the users of thyratrons. This feature is increasing the use of filamentary cathodes rather than heater cathodes in many of the newer designs.

Thyratrons are made in both metal and glass envelopes. Industrial users of this class of tubes tend to favor the metal types on the basis of their being sturdier but cost is the real determining factor in the choice of envelopes. At the present time in considering new designs, an average current rating of about ten amper is the dividing line. For a ratin smaller than this, glass envelopes are indicated and for higher ratings, steel envelopes.

A 25-ampere average current ratin is at present about the largest size o thyratron commercially available. Fo tube current ratings above that valu ignitrons are favored. Thyratrons ar being applied more frequently at highe voltages. An example is in the powe supply for high-frequency heatin equipments.[27]

Quite a number of years ago, th shield-grid design of thyratron[28] wa brought out as a distinct type. No most new thyratron designs have incorporated in their structure wha amounts to a shield electrode. Thei classification as shield-grid thyratrons however, depends upon whether th electrical connection to this shield i part of the cathode structure or whethe it is brought out to a separate bas terminal. In the latter case they ar distinctly in the class of shield-grid tube (Figure 20). In general, this featur of an independent connection to th shield is more common in the smal tubes used entirely for control operations than in the larger tubes where power conversion o power output is usually the predominant use.

Air cooling of thyratrons rather than water cooling i practically universal.

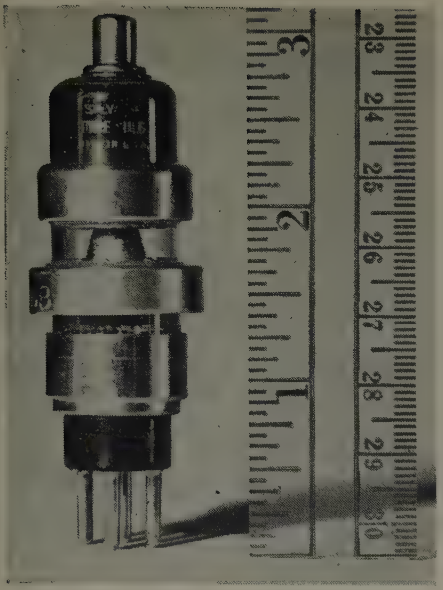
Sealed Ignitrons for Control Applications. There ha not been a great deal of change in design of these tube for a number of years nor in general have any new type of larger or smaller ratings been added. The presen available types seem to be meeting the requirements in satisfactory manner. Use of steel envelopes is almos universal for ignitrons and all except the smallest availabl sizes are designed for water cooling.

Ignitrons for welding control are available and thei application economically sound for use at much lowe average current ratings per anode than in the case of ignitrons for power conversion. This results from the fac that the peak current rating for the tube is the importan factor in welding control rather than the average curren An ignitron with an average current rating of only abou 12 amperes has a peak current rating as high as abou 1,000 amperes for some duty cycles.

Thus we may have the rather surprising combination a 12-ampere average ignitron requiring a thyratron fire it that has a peak current rating considerably highe than this figure.

The sealed type of ignitron has supplanted complete the pumped type in the welding control field.

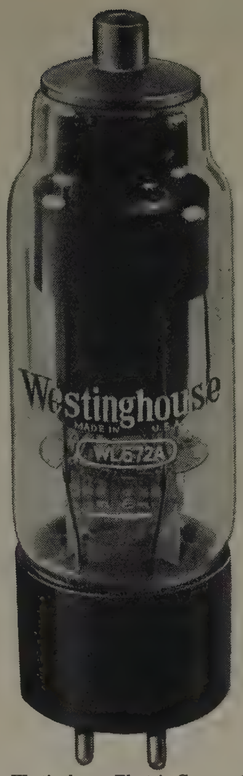
A number of years ago, it was hoped that a pair



Sylvania Electric Products, Inc.

Figure 19 (left). A klystron with frequency range of 2,000 to 4,000 megacycles

Figure 20 (right). Shield-grid thyratron for industrial use



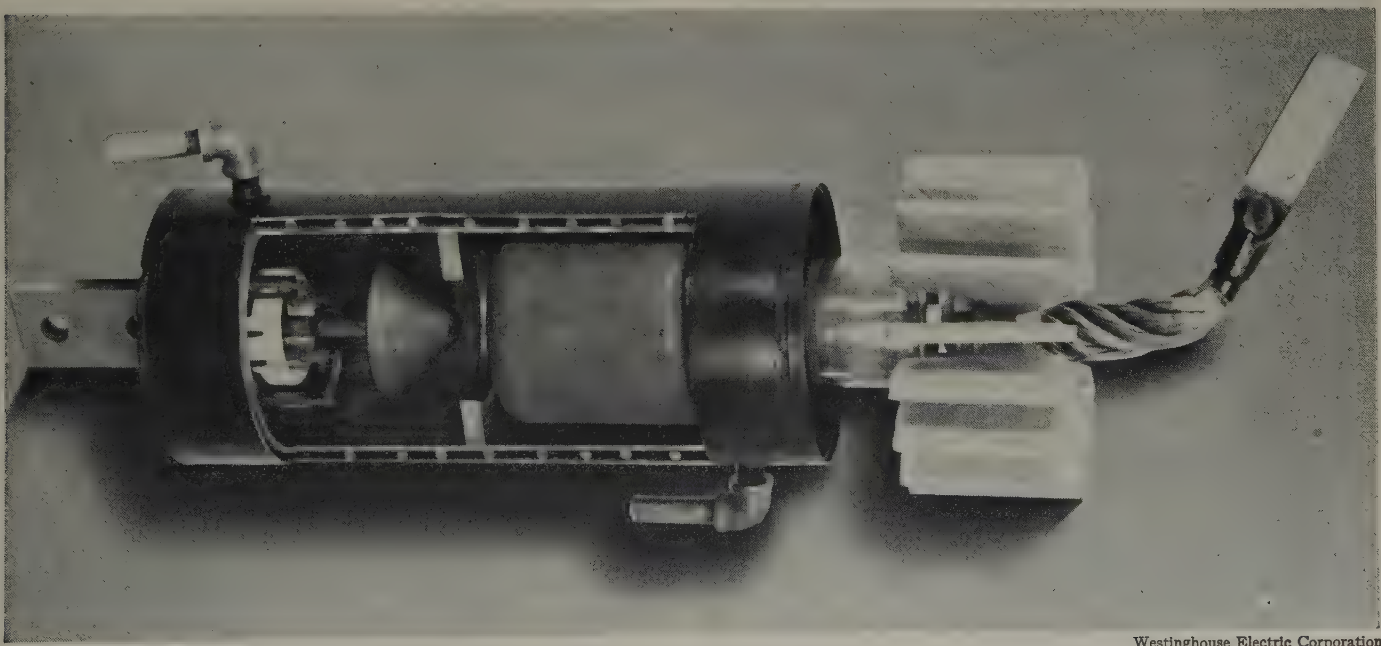
Westinghouse Electric Corporation

ignitrons connected "back to back" constituted an almost universal form of a-c switch or contactor or even a regulator having unusual characteristics that would find many other applications in addition to welding control. To date this hope has not materialized. The most promising new application is in connection with the operation of large d-c motors from an a-c supply line.[29]

SEALED IGNITRONS FOR POWER CONVERSION

One of the most interesting trends in tubes of this class is the marked tendency toward the use of larger sizes. In other words, the line of demarcation between the sealed units and the pumped units is rising to larger and larger ampere ratings. Last year sealed tubes rated at 400 amperes per anode were introduced[30] and now are finding ready acceptance. This represents about a doubling of the amperes per anode over the previous largest size. Another doubling of this factor and a great many of the applications now served by pumped tubes can be handled by sealed-off types.

The single anode type of tube (Figure 21) that always has characterized the ignitron was adopted for the pumped type of rectifier a number of years ago and now almost has superseded, at least in the United States, the multianode unit. In England and Europe, however, multianode tubes are still in the majority and what to American engineers appears to be huge glass bulbs are in common use over there. There has been a decided trend also in the past few years to operate ignitrons at higher voltages[31] than the 250- and 500-volt d-c ratings that formerly comprised the majority of applications. They now are being built and used in connection with power conversion equipments up to 20 kv[32] (Figure 2). They also are finding their place in the power supplies for high-power radio transmitters.[33–35] The sealed ignitron mercury pool tube so far has failed to find application in the lower current ratings. This is not directly caused by any design feature in the tube itself but rather by the fact that the cost of ignitron firing circuits is high and is almost a constant figure regardless of the output rating of the ignitron that it controls. Therefore, as the ratings of a rectifier become



Westinghouse Electric Corporation

Figure 21. Cut-away view of a water-cooled typical sealed steel-envelope ignitron as used for power conversion

smaller and smaller, the expense of the firing circuits does not decrease, and finally the cost of this auxiliary is so high in comparison with the rest of the rectifier that the over-all result is not economically sound. At the present time this lower limit for an economical design of sealed pool tube rectifiers is at about 100 amperes per anode. This situation is a problem confronting engineers active in the development of tubes of this general type for wider applications.

Considerable thought and effort, therefore, are being given to the development of ignitors that require much less current than the present ones that take a maximum of about 25 amperes.[36] This is not an easy problem in view of the outstanding performance of present-day ignitors as regards life and reliability. Life of a modern sealed ignitron is measured in years rather than in a few thousand hours and it requires time to develop new devices with the assurance that these long life records will be maintained.

Most large steel envelope sealed ignitrons contain two separate ignitors. In view of the long average life obtained in modern tubes the question has been raised as to whether two ignitors are really necessary or advantageous. The concensus of opinion seems to be that two ignitors will be continued as a design feature. They represent low-cost accident assurance against ignitor breakage or burn-out resulting from trouble in the firing circuit. Designers of these tubes point out, however, that when a tube finally fails after many years of service it is usually from some other cause than ignitor failure and, therefore, it is seldom that the spare ignitor can be used to rejuvenate completely the tube and start it off on a second career of long life.

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Electrical Essay

Faraday's Law of Induction

If S is any smooth, continuous surface bounded by a single, smooth, continuous closed curve, then always the integral of the electric field intensity E around this closed bounding curve, $\int E_s \cdot ds$ is equal to the negative rate of change of the integral, over the surface of the normal component of the magnetic flux density B.

$$\int E_s dS = -\frac{\partial}{\partial t}\int\int B_N dS$$

True or false?

Answer to Previous Essay

The author's reply to his previously published electrical essay (*EE, Apr '48, p 337*) is as follows.

Don't ask such questions! See Joseph Slepian's "Energy Flow in Electric Systems—the *Vi* Energy-Flow Postulate," AIEE *TRANSACTIONS*, volume 61, 1942, December section, pages 835–40, as to why such questions are without meaning.

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(Associate director, Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Power Plant for a Mexican Industrial Group

VINCENTE ALDAPE C.
APPLICATION PENDING

SCARCITY OF POWER in the city of Monterrey, Nuevo León, Mexico, prompted a group of its most outstanding industries to build a privately operated steam power plant, which would meet not only its present demands, but also satisfy its future needs. The project was engineered by the firm Gibbs and Hill, Inc., of New York, N. Y. Most of this project was developed during the period of World War II, which accounts for several interesting problems that had to be solved to meet the conditions prevailing at the time. The building was built entirely of reinforced concrete, for steel was one of the materials curtailed during the war. The area covered by the building is approximately 25,000 square feet.

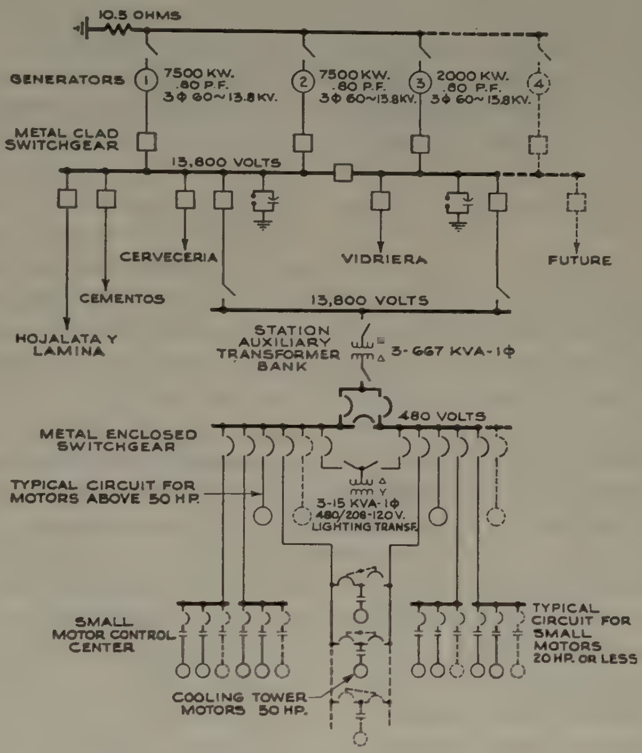

Figure 1. Wiring diagram of the power station

On the ground floor are installed three Babcock and Wilcox integral furnace boilers each capable of delivering 100,000 pounds of steam at 575 pounds per square inch (gage) and 750 degrees Fahrenheit total temperature; the hot process water treatment plant; the boiler control panels; the boiler feed pumps; the circulating pumps and all the other smaller auxiliary equipment. On the main or operating floor are located two General Electric condensing turbogenerators, each rated at 7,500 kw (9,375 kva), 13,800 volts, 3 phase, 60 cycles, and one General Electric noncondensing turbogenerator rated at 2,000 kw (2,500 kva) 13,800 volts, 60 cycles. Besides these units the primary metalclad switchgear, the secondary 440-volt switchgear, the process steam and turbines control panels, and a 300,000 pounds per hour deaerator also are located on this floor. The circuit breakers are lift type, oil filled, rated 600 amperes, 500,000 kva interrupting capacity. A station wiring diagram is shown in Figure 1.

This plant has been arranged for four steam turbine-generator-boiler units, three of which now are installed. The over-all layout has been projected with a view to an ultimate 100 per cent expansion beyond the 4-unit plant.

The plant design was directed toward minimizing the number of operating personnel needed. All pumps, compressor fans, and similar equipment are located on the ground floor. The main steam valves and essential turbine control equipment are located on the operating floor level. No supervision above these levels is necessary except for inspection of deaerator and water softener operation for a few minutes each hour. At present a crew of four men, the watch engineer, the fireman, and two helpers, is enough to take care of the operation of the plant. This plant, while small in size, has all of the operating problems of very much larger plants, and possibly more so because it is an isolated plant with no interconnection with other sources of power generation at the present time.

During the war it was impossible to obtain steam drive for certain plant auxiliaries necessary for starting up without outside power. This made it necessary to avoid shutdown except in extreme emergency. The installation of a tie line now under consideration, between this plant and the local utility company, will make this power immediately available in case of emergency.

Besides the regular electric load served by this plant, it also delivers steam for process work to a brewery (the Cerveceria Cuauhtemoc) and to a paper mill. Because no steam, in the form of condensate, is returned from these customers, the water make-up is considerably large. This makes it necessary to have a very close control in the boiler and treated water to avoid serious damages to the boilers caused by poor or inefficient water treatment.

This plant is strictly modern in every respect and is, without question, one of the most up-to-date plants in Mexico. It has everything available for making it a modern plant and very few plants of its size are as complete. It is a power station of which Mexico justly can be proud.

Digest of paper 48-160, "Industrial Group Builds Own Power Plant," recommended by the AIEE industrial power systems committee and approved by the AIEE technical program committee for presentation at the AIEE summer general meeting, Mexico, Federal District, Mexico, June 21–25, 1948. Not scheduled for publication in AIEE *TRANSACTIONS*.

Vincente Aldape C. is superintendent of the Planta Electrica Grupo Industrial, Monterrey, Nuevo León, Mexico, in co-operation with Gibbs and Hill, Inc., New York, N. Y.

Frequency Response of Recording Instruments

TROY D. GRAYBEAL
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THE DYNAMICS of common types of instrument movements have been studied a great deal, but information dealing with this subject has not been available readily in a form suitable for application work. The behavior of most instruments can be defined by a second order differential equation. In this case the frequency response characteristics can be expressed in terms of the undamped natural frequency and the relative damping. Curves can be plotted in terms of these two parameters to provide a simple and direct method of predicting the magnitudes of instrument errors so that one may decide whether a particular system is satisfactory for a given application, and if so by what margin. The frequency of the signal is expressed as a fraction of the undamped natural frequency of the instrument in order that the curves be applicable universally.

The relative damping and undamped natural frequency may be obtained by simple test methods based upon a-c steady-state or transient response tests, or they may be computed from the physical characteristics of the instrument if sufficient design data are available. Transient tests usually require less complicated testing equipment, and for this reason methods based upon transient tests usually are preferable. The values of undamped natural frequency and relative damping obtained by test methods are subject to some error from imperfections of the instrument, notably friction between the pen and the chart, as well as from the limit of accuracy of making measurements on chart records. The former is not serious in a well-designed properly adjusted instrument, and the latter may be minimized by the choice of a suitable chart speed.

If an instrument is to record accurately at high speed, it must have a high undamped natural frequency, and it must be damped properly. The undamped natural frequency depends upon the inertia of the instrument movement and upon the spring constant of the restoring spring. Once an instrument is built, there is little that can be done by the user of the instrument to increase the undamped natural frequency. The relative damping, on the other hand, is usually to some degree under his control. Electric instruments of the D'Arsonval type and some oscillographs obtain a considerable part of their damping effect from the electric circuit in which the instrument is connected. Thus the relative damping may be changed by changing the resistance of the electric circuit as seen from the instrument terminals. In other instruments damping is introduced by air vanes or by submerging the element in oil. In these instances the damping may be changed by adjusting the air vanes or by the use of an oil of different viscosity.

The frequency response of an instrument is critically dependent upon the relative damping, and for this reason proper damping should be secured before other means are tried for increasing the frequency response. For maximum response, the damping should be somewhat less than 0.7, the exact value being determined by the maximum error that can be permitted in the record obtained. A loss of ten to one or more in frequency response easily can result from improper damping.

It is possible to increase the frequency response of an instrument beyond that obtainable with optimum damping, either by making modifications in the instrument movement to increase the undamped natural frequency, or for D'Arsonval-type movements, by the use of coupling networks between the coil circuit of the instrument and the network where the measurement is to be made. Both these methods present a greater burden by the instrument on the network in which the measurement is to be made. The upper limit that can be achieved practically, depends upon the maximum permissible coil current that will not damage the coil of the instrument from overheating.

At the present time there are available commercially several types of servo-actuated recorders mostly in the form of self-balancing potentiometers. These instruments require a relatively small error signal, of the order of one per cent to five per cent of full scale, to produce maximum velocity of the recording pen. The time required for the pen to move from one end of the chart to the other under this condition is a standard specification of such instruments, and can be used for estimating the maximum frequency, or minimum period, which the instrument will record accurately. Curves (based upon signals of sinusoidal wave form, and neglecting any errors introduced by lags in the servomechanism of the instrument) may be drawn that show the relationship between the minimum period and the peak-to-peak amplitude of a recorded signal for accurate response of a servo-actuated instrument in terms of time required for full scale movement of the recording pen. As long as the period of the signal being recorded is not less than that indicated by these curves, the error in the record obtained at any point will not be greater than the proportional range of the servomechanism. Results obtained from this simplified approach are sufficiently accurate for application work, as one wishes to know the order of magnitude of the minimum period the instrument will record accurately, rather than the value of this minimum period to a high degree of accuracy. When recording irregular wave forms, the fundamental limitation is the maximum rate of change of the signal being recorded expressed in chart divisions per second, and not the fact that the signal contains harmonics as is the case with most other types of instruments.

Digest of paper 48-172, "Frequency Response Characteristics of Recording Instruments," recommended by the AIEE instruments and measurements committee and approved by the AIEE technical program committee for presentation at the AIEE North Eastern District meeting, New Haven, Conn., April 28–30, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Mexico's Steel Industry

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The present rapid industrial growth in Mexico is reflected in her increasing steel production. From its early establishment by the Spanish settlers, steel making has progressed to the point where it promises to be one of the leading industries of Mexico.

THE early history of steel and iron in Mexico is one that would prove most interesting if the facts were available, but unfortunately current historians have no records from which to work. It is known that with the early Spanish settlers, there were several from Toledo, Spain, who set up small iron works based on the blast furnace principle, to make the most urgently needed pieces locally. The exact processes used were as confidential as those employed later by European guilds, and no written record ever was made. These small foundries continued operations with craft secrets being passed from person to person until the turn of this century. There are stories still being told of iron shipments made to the United States in the early 1800's, some of the expeditions taking two years to make the round trip.

IRON ORE AND COKE RESOURCES

There is at present abundant iron ore in Mexico, although only one important deposit is being worked at this time. This is known as "El Cerro del Mercado" located on the outskirts of the city of Durango, Durango and supplying the main part of the ore used in the blast furnaces at Altos Hornos, Coahuila, and Fundidora de Monterrey, Nuevo León. The Republic Steel Corporation has acquired title to large holdings in the state of Veracruz, expecting to be able to ship the iron ore to Atlanta, Ga., by steamer or railroad.

The Bank of Mexico has had detailed reports made of the iron ore deposits throughout Mexico, and these are now available to the general public. Although many of the deposits have not been explored, indications are that there is a supply of sufficient good grade iron available to last for many years.

Coke, an essential element for making pig iron, can be made locally as there are extensive deposits of coking coal in Mexico. At the present time, there is a deficiency in coke production because of the short production of coal and the vast increase in demand for this product by industries, principally those dedicated to nonferrous smelting.

PLANT FACILITIES AND PRODUCTION

The Mexican steel industry output is fairly well controlled by six companies: Cia. Fundidora de Fierro y Acero de Monterrey, Altos Hornos, S. A., La Consolidada, S. A., Laminadora de Acero, S. A., Acero Nacional, S. A., Hojalata y Lámina, S. A.

The Cia. Fundidora de Fierro y Acero de Monterrey, established in 1900, is the largest steel maker in Mexico, with its main plant being located at Monterrey, Nuevo León. The supply of iron is obtained principally from "El Cerro del Mercado," the iron mountain outside of Durango, which is operated by this company in conjunction with several lesser mines. Its coke comes primarily from its own coking ovens at the coal mines. The rest of the ingredients also are obtained from Mexican sources.

The equipment at Monterrey includes one 500- and one 300-ton blast furnace, an 18-ton Bessemer converter, and six 70-ton open-hearth furnaces. The breakdown is accomplished in a steam-engine-driven 42-inch mill followed by 32- and 28-inch mills. Structural shapes up to 12-inch I beams and rails up to 120 pounds are the maximum production size limits. The small mill lineup is 18, 12, and 11 inches for making small shapes and angles.

In addition to the cast iron foundry installation for making car wheels and an electric furnace for special alloy steels, there is a modern bolt and nut plant, a steel wire plant, as well as a fabricating shop where many of the larger railway and automotive bridges have been assembled.

A breakdown of this company's sales reveals the following distribution by per cent of production:

National railways and public works	34.5
Mines and other industry	40.8
Private construction	21.5
Miscellaneous	3.2

The Altos Hornos de Mexico, S. A., plant is located at Monclova, Coahuila, in northern Mexico. Its main goal is to fill the long felt need in Mexico for a plate mill which lack was noted all the more acutely during World War II. American rolling mills co-operated with Nacional Financiera to make possible the carrying out of this project, the former supplying the engineering and assisting in securing the needed equipment, and the latter arranging the financing. The plant contains a 350-ton blast furnace and three 125-ton open-hearth furnaces. A 42-inch 2-high breakdown mill is used for rolling plate for use as such, also the sheet used in the cold roll plate mills. There is one 44-inch and one 38-inch mill where the plate is made for tin plate used in making most of the cans manufactured in Mexico. Their cupola is operating at full capacity for the cast iron pipe mill.

Essentially full text of paper 48-153, "Steel Industry in Mexico," recommended by the AIEE mining metal industry committee and approved by the AIEE technical program committee for presentation at the AIEE summer general meeting, Mexico Federal District, Mexico, June 21–25, 1948; and not scheduled for publication in AIEE *TRANSACTIONS*.

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Altos Hornos recently has installed necessary manufacturing facilities for making large welded steel pipe, and at present is completing the penstock required for the Colimilla project of the Cia. Eléctrica de Chapala. The plate for the new oil line from Poza Rica, Veracruz, to the Atzcapotzalco, Mexico, refinery, a distance of approximately 200 miles, was supplied by Altos Hornos and fabricated in Monterrey by Tubos Soldados, S. A.

La Consolidada, S. A., established in 1907, operates an open hearth plant at Piedras Negras, Coahuila, as the primary source of raw steel. The equipment there consists of two open-hearth furnaces, one 35-ton and one 65-ton capacity. The steel produced is used either at La Consolidada's main plant at Mexico, Federal District, or at the Laminadora de Acero plant at Lechería, Mexico.

The Consolidated's main plant at Mexico City contains a rolling mill, steel foundry, and steel wire, nut and bolt, and springs plants, as well as a copper division. The rolling mill supplies the manufacturing plants with approximately 14,000 tons of steel per year in addition to 14,000 tons being made into small commercial shapes for sale, and about 4,000 tons of copper rod which is supplied to the plant of the copper division.

The National Irrigation Commission and other government agencies are among the larger consumers of reinforcing rod for irrigation dams and various types of construction projects. This rod also was used at the new bull ring and sports stadium, and continues to be in great demand for all classes of private construction. The main customers for steel castings always have been the national railways and the mining companies.

The copper plant at La Consolidada is quite versatile, its products ranging from magnet wires up to the larger low-voltage power cables. It also makes high-voltage polyethylene-insulated vinylite-jacketed cables. Its new magnet wire plant is being set up to manufacture Formvar wires with which it hopes to supply the new electrical manufacturing industry being established in Mexico.

Laminadora de Acero, S. A., started its rolling mill operation late last year. It is equipped with a 30-inch 3-high breakdown mill and a 24-inch billet mill. After a reheat furnace there are installed a 3-stand 16-inch, a 6-stand 14-inch, and a 6-stand 10-inch mill. Its main production will be small shapes and angles. Although operating only one shift at this time, it is expected that the second and third shifts will be added as soon as the operators can be trained. Its production is expected to reach about 60,000 tons per year when the mill operates at full-time capacity.

The 10-inch mill is novel. It consists of six stands with individual motor drive each being rated 200 horsepower. They are installed in tandem on 10-foot centers. The speeds are adjustable over a two-to-one range. This type of mill was selected as being the best arrangement to permit covering the wide range of products it was desired to manufacture. At the time of preparing this article, only four stands have been operated at one time, finishing off with the fourth stand at a speed of 2,300 feet per minute. It is expected to operate the last two stands when making number 5 rod at a delivery speed of 3,200 feet per minute. This mill is one of the first using individual drive for the stands. It has been made possible through the development of sensitive fast responsive control such as the Amplidyne which is used for controlling these 200-horsepower motors. The control desk is located high enough so the operator may watch the loops between the stands and thus have a better chance of making minor speed adjustments before trouble develops from changes in temperature of the steel or roll wear. The experience on the mill so far indicates that the drive will be satisfactory.

The Acero Nacional plant located at Tlalnepantla, Mexico, is similar to that of Laminadora de Acero but its main production will go to the Cia. Nacional de Clavos for manufacture into wires, nails, and so forth. It is planned to go into operation about May 1, 1948.

Hojalata y Lámina, S. A., operates a small mill in Monterrey for making tin plate. Its steel requirements are supplied by a 10-ton electric furnace. Unfortunately few facts are at present available regarding production capacities because the plant only recently began operations.

The total steel production in metric tons for Mexico for the year 1946 has been broken down (one metric ton = 1.102 short tons):

Cia. Fundidora de Monterrey	160,000
Altos Hornos de Mexico	100,000
La Consolidada	40,000
Miscellaneous electric furnaces (estimated)	35,000
Total domestic output	335,000
Importations	280,000
Total consumption in Mexico	615,000

PRESENT AND FUTURE TRENDS

Based on an estimated population in Mexico of 25,000,000, this reveals a consumption of 53 pounds of steel per capita per year. This compares with a consumption of approximately 24 pounds in 1940, or an increase of 120 per cent over a period of six years.

The increase in demand for all types of steel products which in turn occasioned the growth of steel production in Mexico as well as enlarged importations results primarily from extensive programs of both private and governmental construction. The Mexican government under the leadership of both Avila Camacho and Miguel Alemán has initiated and is carrying out a policy of internal development which touches all aspects of Mexican economic life. New highways are being constructed and old ones improved, new bridges are being built as well as transmission lines and towers, irrigation and hydroelectric dams, railway lines, and buildings for government offices. This program ties in with the largest private building boom ever experienced in Mexico.

These two factors more than anything else have combined to raise the position of the local steel industry to its present position. With Mexico undergoing a period of industrial growth similar to that experienced in the United States during the latter part of the 19th and the beginning of the 20th century, it is only reasonable to anticipate that steel making soon will be ranked among the leading industries in this country.

Microwave Attenuation Standard

R. E. GRANTHAM J. J. FREEMAN

A standard of attenuation for microwave measurements has been established using the heterodyne or intermediate-frequency substitution method of calibrating microwave attenuators. A preliminary model of the waveguide-below-cutoff standard attenuator has been built, tested, and improved until its accuracy is within 0.01 decibel per 20 decibels. Accuracy of the entire unit is within 0.02 decibel in the 0–10-decibel range and within 0.2 per cent of the measured attenuation in decibels in the 10–50-decibel range.

BECAUSE of the extremely wide frequency range in the microwave region over which attenuators must be calibrated, the construction of a series of standard microwave attenuators to cover the entire spectrum, and the use of the direct substitution method of calibration, is impracticable. A modification of direct substitution, namely, the heterodyne or intermediate-frequency substitution method, has been adopted by the National Bureau of Standards which permits the comparison of an unknown attenuator, operating at an arbitrary frequency, with a standard attenuator, operating at a fixed frequency. Thus, one standard attenuator, operating at a convenient frequency, may be used to calibrate attenuators over the entire microwave spectrum.

Essentially, the heterodyne method operates as follows: A radio-frequency generator feeds power through an unknown attenuator into a linear frequency converter, which converts the microwave frequency into the intermediate frequency. The converter feeds through an intermediate-frequency standard attenuator into an amplifier followed by a detector and meter. The unknown attenuator then is removed, and the standard attenuator adjusted to give the same meter reading. The attenuation of the unknown is then equal to the increase of attenuation of the standard.

This method assumes that the frequency converter is linear, that is, that the intermediate-frequency power from the converter is proportional to the input microwave power. For small enough input power this is true for a crystal converter, and the operating conditions for a prescribed departure from linearity may be determined experimentally.

The range of attenuation which may be measured by the heterodyne method is less than that measurable by direct substitution, since in the heterodyne method the maximum permissible power input into the converter is limited converter nonlinearity. However, a combination of direct substitution, using a previously calibrated radio-frequency attenuator, together with the heterodyne method, extends the heterodyne attenuation range to that of the direct substitution method, although with a decrease in accuracy.

RANGE OF MEASUREMENT AND ERRORS OF HETERODYNE METHOD

The attenuation range measurable by the heterodyne method is determined by the maximum input power consistent with crystal linearity, and by the crystal noise power. The range of crystal linearity was determined by measuring a fixed value of attenuation as a function of crystal input power.

The crystal noise power was measured to be less than one micromicrowatt, and the maximum range of attenuation measurement corresponding to an error of 0.05 decibel due to crystal noise, is 50 decibels.

In addition to possible crystal nonlinearity, errors in the heterodyne method may occur through radio-frequency or intermediate-frequency leakage, mismatch on either side of the radio-frequency or intermediate-frequency attenuators, frequency and amplitude instability, and errors in the intermediate-frequency standard attenuator. Errors of the intermediate-frequency standard will be discussed in another paragraph, and the question of errors due to mismatch is too lengthy and detailed to consider at this time. If we neglect the last two sources of error, the over-all accuracy of attenuation measurements with the equipment described herein is estimated to be within plus or minus 0.02 decibel in the 0–10-decibel range, and plus or minus 0.2 per cent of the attenuation value in decibels for the 10–50-decibel range.

THEORETICAL FACTORS AFFECTING THE CHOICE AND DESIGN OF THE INTERMEDIATE-FREQUENCY ATTENUATOR

To be suitable as a "standard," the intermediate-frequency attenuator must be able to yield known values of attenuation in terms of an accurately measurable parameter, such as length, or it must be capable of calibration in terms of d-c measurements. First designed by Harnett and Case, the cutoff attenuator (Figure 2), which consists of a hollow tube excited at one end below its cutoff frequency, and a coil or condenser which picks up the attenuated field at the other end, fulfills the former requirement. Because the generated field falls off exponentially with distance from the exciting source, and because the attenuation constant may be computed from the dimensions of the tube, the ratio of any two voltages, or the attenuation introduced by a given length of tube, is reduced to a measurement of length.

Essential substance of paper 48-44, "A Standard of Attenuation for Microwave Measurements," recommended by the AIEE instruments and measurements committee and approved by the AIEE technical program committee for presentation at the AIEE winter general meeting, Pittsburgh, Pa., January 26–30, 1948; and scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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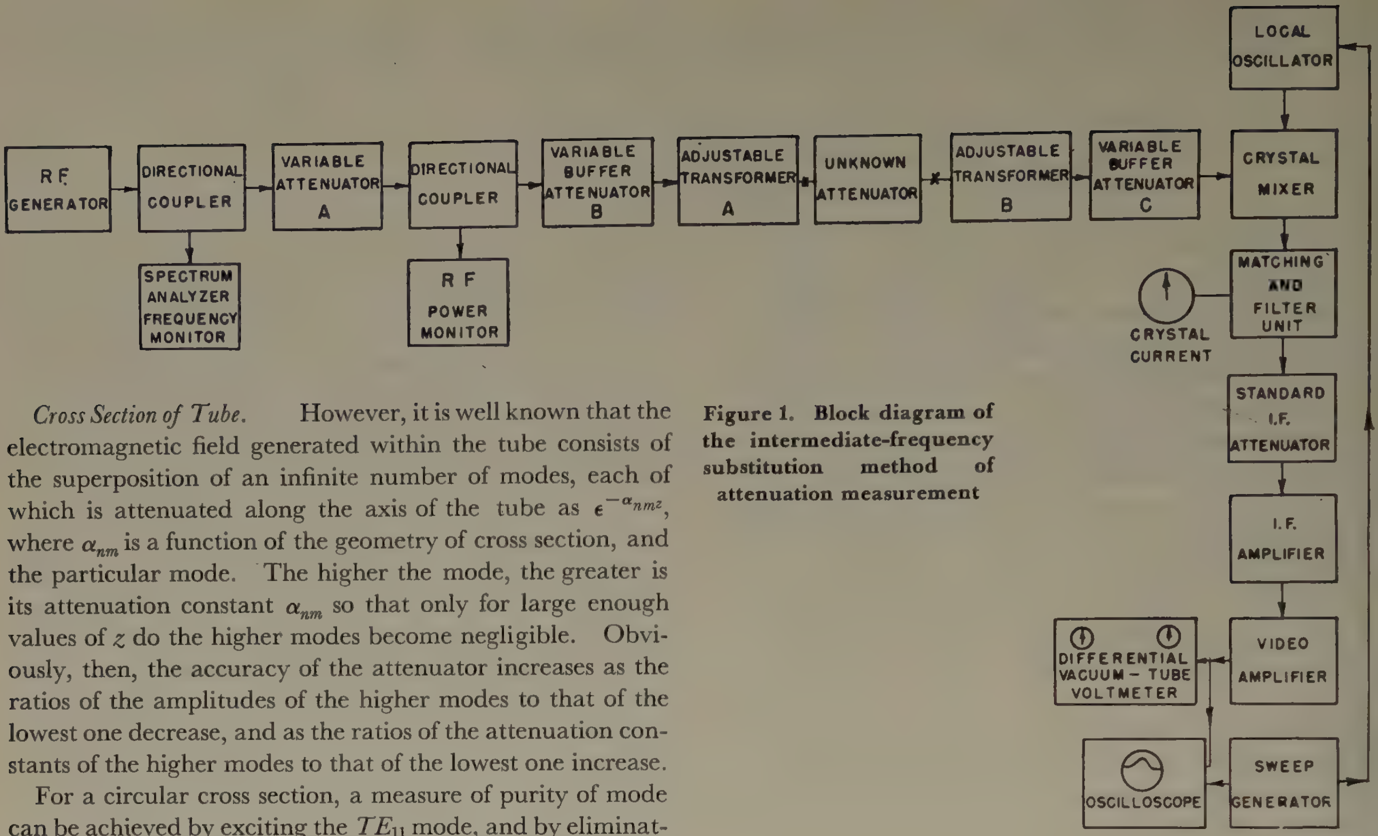


Figure 1. **Block diagram of the intermediate-frequency substitution method of attenuation measurement**

Cross Section of Tube. However, it is well known that the electromagnetic field generated within the tube consists of the superposition of an infinite number of modes, each of which is attenuated along the axis of the tube as $\epsilon^{-\alpha_{nm}z}$, where α_{nm} is a function of the geometry of cross section, and the particular mode. The higher the mode, the greater is its attenuation constant α_{nm} so that only for large enough values of z do the higher modes become negligible. Obviously, then, the accuracy of the attenuator increases as the ratios of the amplitudes of the higher modes to that of the lowest one decrease, and as the ratios of the attenuation constants of the higher modes to that of the lowest one increase.

For a circular cross section, a measure of purity of mode can be achieved by exciting the TE_{11} mode, and by eliminating the TE_{01}, TE_{21}, and TM_{01} modes through symmetry of excitation. Just as a violin string plucked in the center does not vibrate with even harmonic modes, similarly, a proper symmetry of the exciting current distribution in a cutoff attenuator will not excite certain classes of modes. In particular, if one considers the cross section divided into four symmetrical quadrants, and if the current distribution in the right-hand quadrants is the negative mirror image of that in the left-hand quadrants, and if the current distribution in the upper quadrants is the positive mirror image of that in the lower quadrants, then only those modes will be excited for which n, (the mode index indicating angular dependence) is odd, eliminating five of the seven undesired modes. However, if one uses an unbalanced generator to excite the attenuator coil, the distributed capacitance of the coil makes the achievement of this symmetry difficult.

The obvious type of exciting symmetry associated with a circular tube is, of course, circular symmetry. In particular, circularly-symmetric capacitative disk excitation will excite only transverse magnetic modes, for which $n=0$; of these the mode with the lowest attenuation constant is the TM_{01}. The danger with this type of attenuator is that any assymmetry will produce a TE_{11} mode which has a lower attenuation constant, and hence, for a large enough value of attenuation, can lead to appreciable error.

For rectangular cross sections with a width to depth relation of $a=b/2$, or less, the unwanted modes decay much faster than for circular cross section. Also, if the exciting-current distribution is chosen so that to each element of current corresponds its negative mirror image with respect to the plane $x=a/2$, and its positive mirror image with respect to the plane $y=b/2$, then it may be shown that only those modes are excited for which m is even and n is odd. Although this type of symmetry is difficult to achieve at lower frequencies, using coil structures, at microwave frequencies this type of symmetry should be easily obtainable using symmetric windows as the exciting structures.

Reaction Effect. The reaction of the receiver circuit on the exciting current becomes the limiting factor affecting the closeness of spacing between exciter and receiver, when precautions have been taken to reduce the unwanted modes. A further advantage of the TE_{11} mode over the TM_{01} mode attenuator is the smaller interaction between exciting and receiving circuits for a given attenuation.

Skin Effect. For a circular intermediate-frequency attenuator with a radius much less than one wave length, there is no correction for the TM_{01} mode, whereas the effects of finite conductivity is such as to increase the effective radius

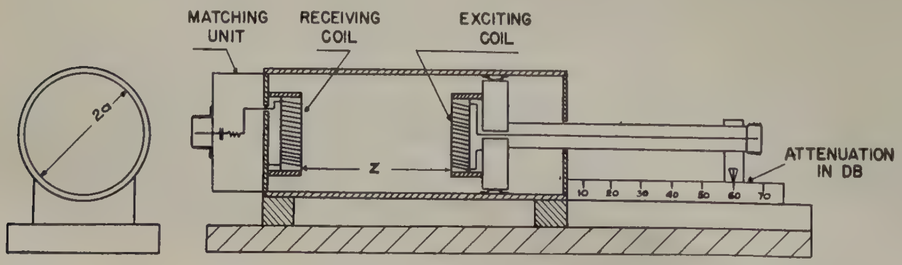
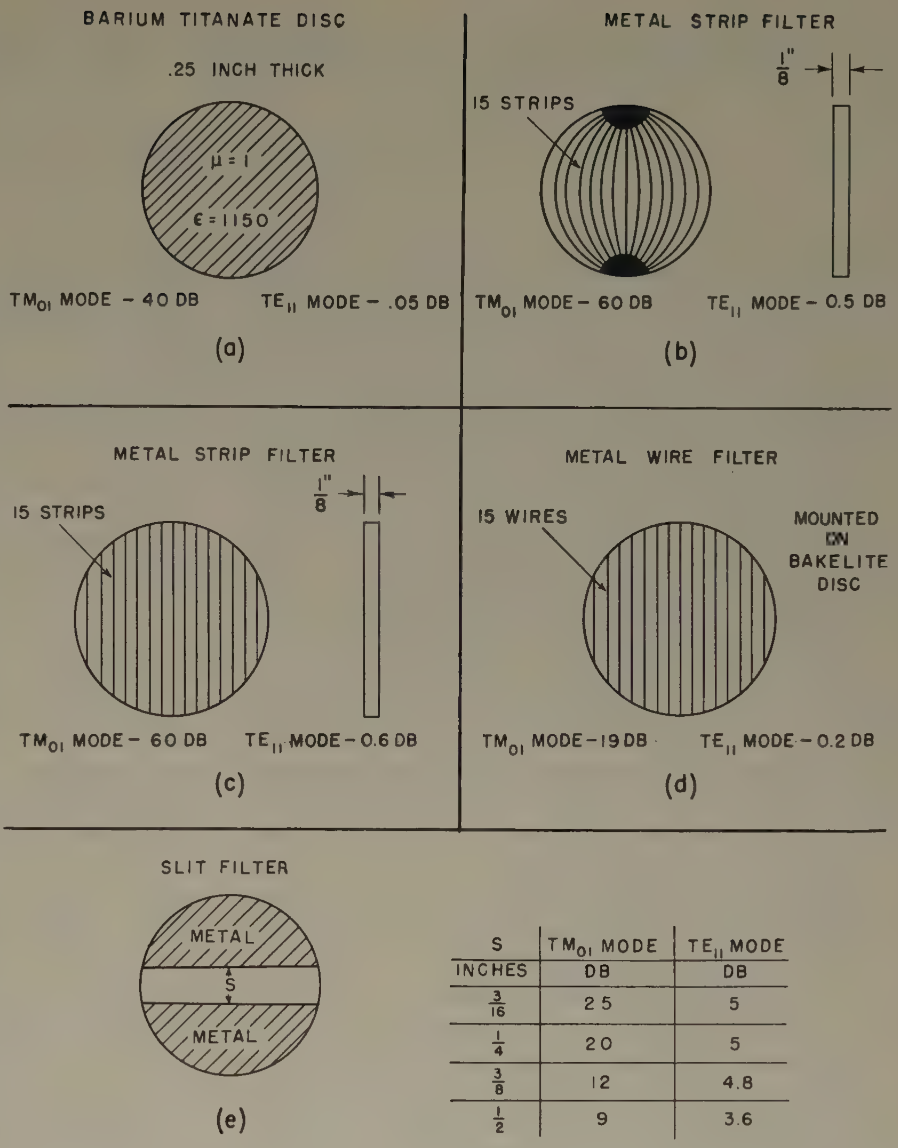


Figure 2. **Schematic diagram of the standard waveguide-below-cutoff attenuator**

Figure 3. Insertion loss of various mode filters for TE_{11} and TM_{01} modes in the cutoff attenuator



S INCHES	TM_{01} MODE DB	TE_{11} MODE DB
$\frac{3}{16}$	25	5
$\frac{1}{4}$	20	5
$\frac{3}{8}$	12	4.8
$\frac{1}{2}$	9	3.6

from a to $a+(\delta/2)$ for the TE_{11} mode, where δ is the skin depth.

EXPERIMENTAL EVALUATION OF CUTOFF ATTENUATOR

A circular waveguide-below-cutoff attenuator was built for operation at 20 megacycles with the TE_{11} mode having an attenuation rate of 21 decibels per inch. The distance between coils is adjusted by a mechanical screw drive, and a mechanical counter reads the attenuation directly in units of 0.01 decibel. Rectangular coils mounted on precision-made bakelite forms are used in an effort to secure symmetry in the generation of the TE_{11} mode, and hence reduce the unwanted modes. The mechanical precision of construction is such that the accuracy of attenuation reading is plus or minus 0.01 decibel per inch.

Linearity. Measurements of the attenuation of a particular 5-decibel step of a carbon attenuator were made for different separations of the coils in the cutoff attenuator, and were found to be constant within experimental error (plus or minus 0.01 decibel), for coil separations greater than 20 decibels (about one inch). For smaller separations, the measured values of attenuation were variable, depending upon the angle between the axes of the coils. This departure from linearity was caused partly by the change in exciting current because of coupled impedance of the secondary coil, and also partly by the presence of higher order modes.

Relative Amplitudes of Higher Modes. Measurements on the experimental TE_{11} mode cutoff attenuator, using rectangular coils, showed that the angular calibration was symmetrical within the accuracy of the measurement, and it was concluded that there was no appreciable detrimental coupling resulting from modes which were higher than the TM_{01}.

However for a minimum coil separation corresponding to an attenuation from the TM_{01} mode of 20 decibels, the maximum error in attenuation was measured to be 0.08 decibel, using an angular calibration. The latter error was not detected by measuring the 5-decibel step of the carbon attenuator because the error was spread over such a wide range of attenuation that the amount included in a 5-decibel interval was smaller than the experimental error. The mode filters described subsequently were devised to eliminate this error.

Mode Filters. It can be shown mathematically that a material of high dielectric constant will reflect the TM wave and pass unchanged the TE wave.

The measured insertion loss of a barium titanate disk of 0.25 inch in thickness, having a dielectric constant of 1,150, was 40 decibels for the TM_{01} mode, and 0.05 decibel for the TE_{11} mode. To insure an intimate contact between the barium titanate and the inside surface of the cutoff attenuator, the rim of the disk was silvered.

Various types of metal filters were tried. They are illustrated in Figure 3 and their insertion losses given. The mode filter which is shown in Figure 3C was incorporated into the attenuator.

Comparison with a Carbon Attenuator. A calibration of a Leeds and Northrup carbon attenuator was made over a 40-decibel range in attenuation at 20 megacycles. The resulting attenuation calibration checked within 0.03 decibel the calibration made with direct current. A check then was made by operating the cutoff attenuator as a TM_{01} attenuator as described for TM_{01} mode-filter insertion loss. The TM_{01} mode calibration was made at only two values of attenuation, 10 and 20 decibels, and the values obtained checked the previous calibration within plus or minus 0.01 decibel.

Forming Oxide Films on Electrical Steel

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VARIOUS METHODS have been devised for producing an insulating film on the surface of electrical steel laminations for the purpose of minimizing interlaminar eddy currents when the core comprising the laminations carries an alternating magnetic flux. The formation of an insulating oxide film on the surface of the laminations appears to be advantageous from a production standpoint because it does not necessitate the handling of individual laminations, which is required when varnishes or the like are applied, and because the oxidation process can be combined with a strain annealing operation which is undertaken when the optimum magnetic properties of the magnetic material are desired. If the oxide is formed in an air atmosphere at low temperatures, as where it is desired to insulate the laminations only and not to strain-anneal them, then the characteristics of the product are undesirably variable in that sometimes red ferric oxide is formed while at other times blue-black magnetic oxide is formed. Ferric oxide, common red rust, is undesirable because its thickness causes poor space factor in the core and because it is not tightly adherent. When properly produced, the magnetic oxide (Fe_3O_4) is tightly adherent, thin, and provides satisfactory interlaminar resistance.

A process was developed for consistently obtaining the tightly adherent, highly resistant, blue-black oxide at low temperatures. This process consists of treating the laminations at a temperature between 400 degrees centigrade and 550 degrees centigrade in either a batch-type or a continuous furnace in essentially a 100 per cent steam atmosphere. Provision must be made to exclude free oxygen from the furnace since as little as one-half per cent by volume causes formation of red rust. This process has proved very satisfactory in instances where complete strain annealing is not required and an interlamination resistance of 20 ohm-centimeters squared per lamination, or better, is obtained when one per cent silicon steel is oxidized in this manner.

When strain annealing is required, it is apparent that drastic oxidation resulting in scale would occur if punchings were treated at the annealing temperature in an oxidizing atmosphere such as steam. A continuous method was attempted in which the laminations were strain-annealed in a conventional continuous pusher-type furnace consisting of a high temperature zone, a controlled cooling zone, and a fast cooling zone. A reducing combusted gas atmosphere was admitted to the high temperature zone of the furnace and steam was admitted to the controlled cooling zone to promote oxidation. This process gave a fairly consistent product with an appearance similar to that obtained in the low temperature oxidation process in steam, but the interlaminar resistance was found to be on the average about 1/100 of the resistance obtained in the low temperature process.

An investigation was carried out to determine the difference between high resistance and low resistance films which had no appreciable difference in physical characteristics. X-ray diffraction studies of the two types of films disclosed that the low resistance film, formed in conjunction with the strain anneal, contained a large amount of metallic iron, while the high resistance film, formed below 550 degrees centigrade, did not. It was found in the literature on this subject that ferrous oxide (FeO) is formed in a controlled oxidizing atmosphere above 570 degrees centigrade and that, if the oxide subsequently is cooled slowly below 570 degrees centigrade, the FeO decomposes to form Fe_3O_4 and metallic iron. As the low resistance film contained as much as 50 per cent metallic iron, it was concluded that these films were formed above 570 degrees centigrade because of the back diffusion of steam into the hot zone of the furnace, and that the low resistance of the film was the result of the contamination of the Fe_3O_4 film with conductive metallic iron particles.

To obtain a high resistance oxide film in a continuous strain annealing and oxidizing process, it is necessary then to prevent oxidation above 570 degrees centigrade. It is almost impossible to carry out this procedure in a conventional type of continuous furnace. A special type of furnace is necessary to produce the satisfactory oxide in conjunction with a continuous annealing process. This furnace consists of an annealing zone and an oxidizing zone separated by a gas-tight transfer chamber. A reducing atmosphere is maintained in the annealing zone and the transfer chamber, and an oxidizing atmosphere such as steam is supplied to the oxidizing zone. The punchings are cooled to a temperature below 570 degrees centigrade before entering the oxidizing chamber of the furnace, and the transfer zone is so arranged that it will serve to keep the oxidizing atmosphere from contaminating the reducing atmosphere in the annealing zone.

The following conclusions have been reached as a result of this investigation:

1. Low resistivity of oxide films is caused by conducting particles of metallic iron distributed throughout the film.

2. The oxide film, which is formed in the conventional continuous annealing and oxidizing process, contains a large amount of metallic iron caused by the oxidation occurring above 570 degrees centigrade. At this temperature FeO is formed which later decomposes into Fe_3O_4 and Fe.

3. To obtain a film which is not contaminated with metallic iron, it is necessary to carry out the oxidation below 570 degrees centigrade. If annealing as well as oxidation is desired, the punchings must remain bright during the annealing cycle and while they are cooling to the oxidizing temperature.

Digest of paper **48-120**, "Formation of Oxide Films on Electrical Steel," recommended by the AIEE rotating machinery and transformer committees, and approved by the AIEE technical program committee for presentation at the AIEE summer general meeting, Mexico, Federal District, Mexico, June 21–25, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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The "Director" for Automatic Telephone Switching Systems

ARTHUR BESSEY SMITH
FELLOW AIEE

The flexibility of the "Director" is pointed out by this description and explanation of how it works and the variety of things it can do. It eliminates the necessity of direct trunks between all offices without forfeiting universal numbering.

THE TELEGRAPH was invented in 1837 by Samuel F. B. Morse. In 1876 came the invention of the telephone by Alexander Graham Bell. By this time the switching of telegraph lines had developed into a definite system, characterized by plugs and jacks for easy connection and disconnection. Each connection lasted for a relatively long time, hours often running into days.

The first telephone switchboards were very much like the telegraph switchboards. But the telephone naturally required many connections and disconnections per hour, each connection lasting only a few minutes. This led to making the plugs and jacks smaller and more easy to handle.

It is a remarkable fact that very soon after Bell's invention the first attempts were made to do the telephone switching automatically ("to do by a machine that which formerly was done by hand"). And about 1891 the work of Almon B. Strowger got started, which developed into that of the Automatic Electric Company. It was the adoption of that system of automatic switching for the London, England, telephone exchange that led to the invention and development of the "Director," which is the subject of this article.

The Director is a telephone switching device which stores the dialed call number and then sends out decimal impulses which guide the connection to the desired telephone office and to the called line.

When electric light and power came to London, the authorities ruled that all wires must be laid underground. The first telephone system in London, like others of that era, was manual, and was forced to put its wires underground.

In addition to slowing the growth of telephone use, this tended to fix the routes of telephone cables and to make it difficult to open new routes between offices as new offices were opened. To use tandem trunking was cheaper than to install direct trunks between all offices.

Direct trunks with straightforward dialing has much to commend it. There being no Director, there is no storage of impulses and no loss of time due to that. The subscriber pulls the call number, and when the dial gets home from the last digit, the connector has arrived at the called line. There remains only the short time to test the line, and if free, to start the ringing, which the subscriber can hear. Also, there is the psychological aspect—he has been usefully employed during the time and his wait is short.

It is tandem trunking which makes the Director necessary, as also the great desirability to be able to call a certain telephone by the same call number no matter where the calling subscriber may be located—the universal numbering plan. Tandem trunking and the Director have been very much considered in America also. In fact, the Director was installed in Havana, Cuba, and in a private automatic exchange in Kansas City, Mo., before the London system was put into service.

There are also cases in small communities where the Director will serve. If it is desired to permit subscribers to dial over a county, without any intervening operators, many of the paths will pass through switching points, and others may use direct trunks.

The present-day prospect of nation-wide toll dialing in the United States, for which the Director is ideally suited, is one of the chief reasons for calling the Director to your attention at this time.

UNIVERSAL NUMBERING

Consider two small towns, not too far apart, each served by a 100-line automatic switchboard, with only 80 lines in use. Figure 1 (without the dotted lines) illustrates the condition. All calls in each town are made with two digits, and only connectors are needed.

If someone gets the idea of permitting the subscribers freely to dial each other between the two switchboards, the dotted lines and switches may be added. There may be incoming connectors C' whose banks are multipled onto the banks of the local connectors, C. Suppose that the top level of each local connector is set aside for trunking to the other board. Thus, any subscriber in M will dial two digits to get others in his same town, but must prefix 0 to get any telephone in J. Likewise, any J subscriber must prefix 0 to get any telephone in M.

The following situation arises. To call telephone *25* in the M region, dialing from any other telephone on the M

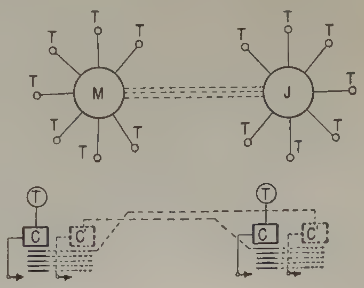

Figure 1. Two exchanges, not universal numbering

Essentially full text of paper **48-99**, "The "Director" for Automatic Telephone Switching Systems," recommended by the AIEE communication committee and approved by the AIEE technical program committee for presentation at the AIEE winter general meeting, Pittsburgh, Pa., January 26–30, 1948; and scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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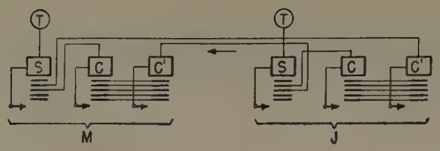


Figure 2. Two exchanges, universal numbering

switchboard, requires the dialing of only *2* and *5*. But to dial the same telephone from any telephone connected to the *J* switchboard requires the user to dial *025*. This is *not* universal.

Now consider Figure 2. Each of the two switchboards now has selectors *S* as well as connectors *C*. Every telephone has a 3-digit call number. As sketched, the telephones in *M* are in the 300 group and those in *J* are in the 400 group. The former telephone *25* in *M* now can be called by dialing *325* in either town. It is thus with all the telephones. This is *universal numbering*.

TANDEM TRUNKING

Let the four offices, *E*, *J*, *K*, *M*, of a multioffice exchange be interconnected as usual by direct trunks Figure 3. To serve a new region, office *X* is built. By reason of the local geography it would be too expensive to install direct trunk groups between the new office, *X*, and each of the older offices. Hence it is decided to have all calls from and to the *X* office switched at *J*. Any call from *E* or *K* or *M* would be dialed to *J*, where an additional digit would reveal that the call goes to *X* instead of the telephones connected to *J*. This is tandem trunking. If there is no Director, or its equivalent, this cannot have universal numbering.

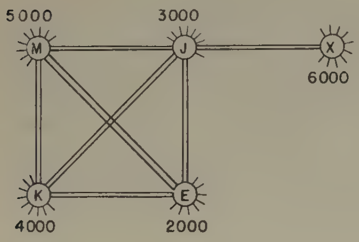


Figure 3. Tandem trunking

Also notice this, if a subscriber in *J* calls one in *X*, he will dial perhaps 4 digits. But if a subscriber in *E*, *K*, or *M* desires to call a telephone in *X*, he must first dial a digit to get to *J*, then followed by the call number for the *X* telephone. Thus the number actually dialed will depend on where the caller is located, and it is not universal numbering.

This problem can be solved by placing in each of the five offices a number of switching devices known as Directors. Each of these has been so designed that it can direct or guide a call to the desired distant office no matter what route it must take. Each of these Directors is accessible to all calls coming from subscribers in that office. It is convenient to arrange it so that when a subscriber initiates a call, he will as usual get a first selector, and an idle Director at once will be associated with that first selector. The entire call number (for example, *6258*) will be dialed into the Director, and registered there. The Director has been endowed with enough electrical and mechanical judgment to know, from the first digit, *6*, that it first must send the digit *3* into the first selector to extend the line to the *J* office, to follow this by digit *6* into an incoming selector in the *J* office to cause it to rise to the group of trunks leading to the *X* office. After this, the Director will send the rest of the call number *258*, which operates switches in the *X* office to connect the desired line. The other offices are likewise equipped with Directors having equal abilities, so that no matter where you are in the city, you can dial your friend in office *X* by the one call number, and you will get the right telephone. This is how the Director permits *universal numbering*.

THE LONDON AUTOMATIC TELEPHONE EXCHANGE

On about January 1, 1922, the Automatic Electric Company was asked to develop an apparatus which would enable the London exchange to convert to automatic switching without installing direct trunks between all offices. Regular Strowger-type numerical switches would switch the connections to their destinations.

M. L. Nelson and R. G. Richardson worked out the general plan and the circuit details and by January 6 they completed the first drawing showing practically all the details of a working Director. Though there have been numerous changes, yet many of the features of that first layout were fundamental and have remained for that reason.

In the year 1924 a Director system was built and installed in the Havana, Cuba, exchange.

In the spring of 1923 John E. Ostline went to England in charge of the further development of the circuits, and out of his work have come many improvements, some of great economic value. In 1924 they began to build the apparatus for London, and in 1927 the first of it was put into service. Since then the progress of development has been fairly steady.

First Aspects of the London Director. The situation may be illustrated by the following things which presented themselves to the designer:

1. The universal call number, such as *DAVis-8019*.
2. Tandem trunking.

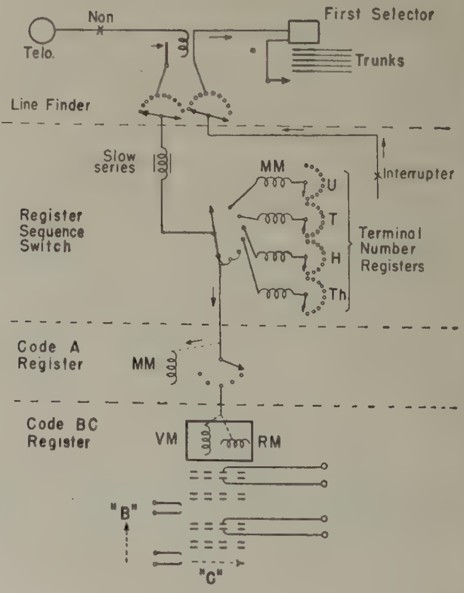


Figure 4. London, England, plan, general, call registry

3. Straight Strowger dialing of impulses, clear through to the distant office.

4. Trunk to manual offices with call indicators for the operators at least during the transition period.

The use of the name of an office (such as Davis, Monroe, Humboldt) is a device to aid the memory of the user. It makes it more easy to remember the number from seeing it in the directory to spelling it out on the dial. The arrangement of the letters of the alphabet on the dial is well known. The first letters of the office name, which are to be dialed, are known as the office code, such as *DAV*. Dialing it results in a decimal equivalent such as *328*.

The coming of the Director has required the use of certain words and expressions, each to have a definite and clear meaning, so as to avoid confusion. I will illustrate by the call number *DAVis-8019*.

1. *DAV* is the office code.
2. *328* is the decimal equivalent of the office code.
3. *MNOP* or other digits form the directive. By the action of the Director they are derived from the office code and they guide the call to the distant office. The number of digits in a directive depends on the route.
4. Directive selectors are those which are in the train leading to the distant office. Each is operated by one digit of the directive.
5. *8019* is the terminal number. As usual, the digits are called thousands, hundreds, tens, and units.
6. The thousands selector and the hundreds selector are in the distant office and handle the digits indicated by their names.
7. The connector connects to the called terminal.

The London situation led to the following first approach.

1. Carry the terminal number through unchanged (such as *8019*).
2. Transform the decimal equivalent (such as *328*) into a directive (one to six digits) to steer the call to the distant office.
3. The Director was required to store all digits dialed by the subscriber, transform the decimal equivalent of the office code into a directive, send it, and repeat the terminal number unchanged.

The Director was composed of the following subordinate devices:

1. The inward path, which guides the dialed impulses into the Director.
2. The *ABC* register, on which the three decimal equivalent digits are stored.
3. The terminal number register, on which the four digits of the terminal number were stored. There was no provision for party lines.
4. A register sequence switch to guide the incoming digits, each to its appropriate register.

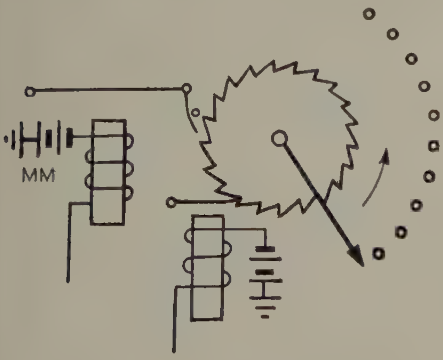


Figure 5. Ratchet magnet, direct drive

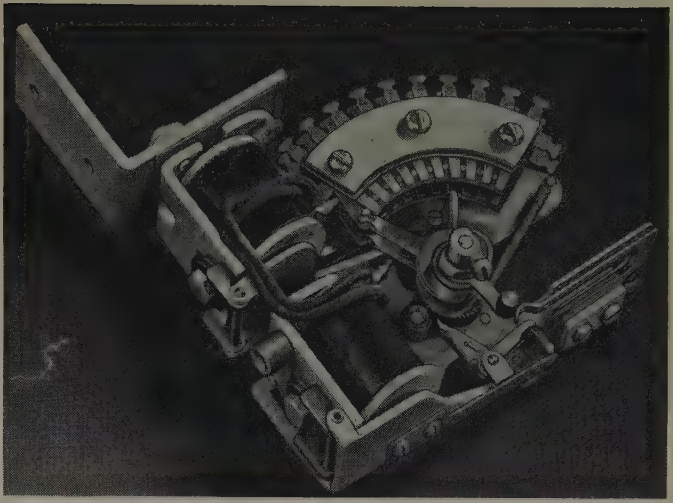


Figure 6. Minor switch

5. A translator, to change the *ABC* code (its decimal equivalent) into from one to six digits, called the directive.
6. An outward path from the Director to the first directive selector (in the first office), from which place the path will be extended to the distant office and the called line.
7. An impulse generator, a device which generates correct impulses to be sent over the outward path.

The following examination of certain key circuit devices will use "outline symbols," combined to show the general relationships, and describe several circuit devices and their combinations to reveal the structure and action. To save space, some symbols will be used without explanation.

Call Registry. The registry of the call number is outlined in Figure 4. The telephone line comes through such nonnumerical switches (*Non*) as are used. These may be line switches or line finder switches. The trunk passes to a group of trunk relays, where two chief paths run to the banks of a group of line finders, presided over by a call distributor. The latter sends one of the line finders to seek the incoming call. Thus it is connected to an idle Director. Only the registry parts are here indicated by single line diagrams and symbols.

The incoming path from the subscriber passes through a slow relay (*slow series*) to the wiper of the register sequence switch. From the bank of this switch lead wires to the *ABC* code register and to the four digit registers for the terminal number (*Th*, *H*, *T* and *U*).

The *A* digit (for example $D=3$) operates the motor magnet *MM* of the code *A* register to contact *3* on the bank. At the same time, the slow relay has energized the motor magnet of the sequence switch, so that at the end of the impulses the slow relay falls back and de-energizes the motor magnet, whereupon the wiper moves to the next bank contact. The next two digits from the telephone operate first the vertical magnet *VM* and then the rotary magnet *RM* of the code *BC* register. This is a 2-motion Strowger switch. The second digit (for example $A=2$) lifts the wipers to the second level, and the third digit (for example $V=8$) rotates the same wipers to the eighth set of contacts on that level. In the meantime, the slow series relay of the sequence switch has advanced the wiper to contact *4*.

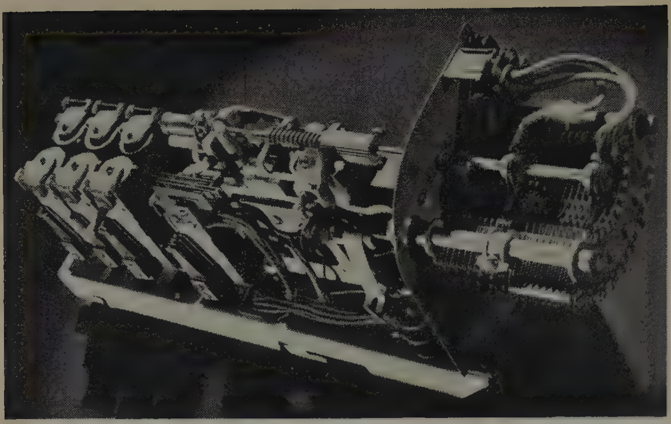


Figure 7. Strowger switch

It is now clear how the remaining digits for the terminal number are directed successively to the motor magnets for the thousands, hundreds, tens, and units registers.

Thus by the positions of the wipers of the *BC* register we have a recording of the office code (its decimal equivalent) and by the positions of the four wipers of the terminal register an indication of the terminal number as it appears in the telephone directory.

Magnet Ratchets. Two ratchet devices are used, each with its own properties and performances. They enable circuit designers to obtain valuable results.

Figure 5 illustrates the direct magnet drive, used in the minor switch of Figure 6 and in the vertical and rotary movements of the Strowger switch, Figure 7. When the magnet, Figure 5, is energized, the wipers move to the next contact. When the magnet releases, there is no circuit change—the ratchet is made ready for the next step. Such a ratchet action moves against a restoring force, gravity in the vertical movement of the Strowger switch and a spring in the rotary motion, as also in the minor switch. In each case there is a detent, holding the ratchet teeth from moving backward. Return to normal is by a release magnet which pulls out the detent. The minor switch is used for the register of the digits of the terminal number and the Strowger switch for the *BC* code register.

Figure 8 illustrates the spring drive, used in the rotary line switch Figure 9. When the magnet, Figure 8, is energized, the pawl engages the next tooth but the wipers do not move. When the magnet releases, the spring drives the wipers to the next contact. This kind of switch is returned to normal by causing the motor magnet to buzz like a doorbell, so driving the wipers around the circle to the home position. This is used in the register sequence switch and elsewhere.

The Impulse Sender. The basic principle by means of which properly registered digits can be sent over the outgoing path or loop to the selectors is illustrated by Figure 10. Suppose that each of the three registers, *H*, *T*, and *U*, can be set by hand to any desired digits. I will assume *3-2-5*. Let the sequence switch *Seq* be arranged to be moved by hand from its home contact to each of its bank contacts in sequence.

The impulse sender itself, as here abstracted, consists of a rotary switch with wipers *W* and *W′*, stepped by a motor magnet, *MM*. This is of the spring-drive type. A stop relay is connected to the wiper *W*.

In the upper right corner of the figure is the loop leading to the first selector, and through it to other selectors in the train. Two relays close it normally, by their back contacts, relay *D*, wired to wiper *W′*, and the interrupter relay *IR*, controlled by the interrupter itself. The interrupter *I* is running steadily at the rate of ten impulses per second, and the ratio of break to entire period is correct to operate the numerical switches in the train.

Two functions are essential, to start interruptions of the loop with a full-time break (not part of one) and to stop the sending when there have been sent the number of breaks indicated by the setting of any one of the registers.

Let wiper *H* be hand set to *3*, *T* to *2*, and *U* to *5;* and the sequence switch set onto the *H* contact of its bank. Then the start key is pressed and held down. If the time of pressing happens to be too late in an impulse of the interrupter, relay *IR* will fail to pull up, or make a feeble or partial response. This does no harm. But the next time *I* closes, it will operate *IR* for the full time. This energizes the motor magnet, *MM*, which pulls its armature to cause its pawl to engage a tooth. When *IR* falls back, *MM* will de-energize and drive the wipers *W* and *W′* to the next contacts. Here *W′* operates relay *D*, which pulls up and remains operated to the end of this digit, opening its contact and thereby putting the loop entirely into the control of the *IR* relay.

The next impulse from *I* operates *IR* as before, which causes *MM* to advance the wipers to contact *1*. The arrival of wiper *W* at contact *1* permits the stop relay to find out if it is grounded. It is not, so two more impulses bring the wipers to contact *3*, which is grounded by our setting of the *H* register and the position of the sequence switch. At once the stop relay pulls up, breaks the start wire, and ends the sending of three impulses over the loop. There were only three impulses and all of them were perfect.

In addition to stopping the impulses, the stop relay locks itself to ground on a contact of relay *D*, also connects the self-interrupter contact of the motor magnet to wiper *W′*. At once the motor magnet starts to vibrate and thus drives the wipers *W* and *W′* around the circle to the home position. Here the ground is removed from *MM* and relay *D*, the latter releases the stop relay, and ("start" being opened) the sender is ready for the next digit. Now the sequence switch may be moved to the *T* contact, the start key closed, and the sender will do the same process all over again, this time sending two good impulses. Moving the sequence switch to *U* will cause the same to be done for the units digit.

Translation—Decimal Equivalent Into Directive. Consider

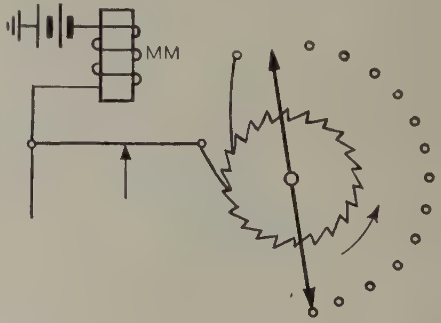


Figure 8. Ratchet magnet, spring drive

the *ABC* code registers which were discussed in Figure 4. The *A* register is a simple rotary switch of the "minor switch" type, and is set by the decimal equivalent of the first letter. This connected the impulse circuit to the vertical magnet, then to the rotary magnet of the selected *BC* register. This Strowger switch registered the *B* and *C* digits by its "up and around" movement of four wipers.

Now consider Figure 11 which illustrates the translation of the decimal equivalent of the office code.

Each Director has one code *A* register, to whose bank are wired eight code *BC* registers. I have illustrated this by only three of them. From the *A* register bank contacts the wires run to the magnets of the *BC* switches. The wipers of all the *BC* switches are multipled, each to each, and run to the bank of the sender sequence switch. The banks of the *BC* switches are wired separately to one side of an intermediate distributing frame, *IDF*. The other side of that *IDF* is wired to the bank of the sender switch, where the sending of impulses over the loop will be governed. In this simplified illustration I have shown only two wipers for each *BC* switch. There were six wipers on each switch as planned for London.

Assume the following relations:

Decimal equivalent	Directive
243	32
324	41
433	53

On the *IDF*, jumpers would be run as shown. For example, the number *2 BC* switch bank contact *43* would have its bottom contact of the pair wired to *3* on the right side and its upper mate wired to *2* on the right side. The other jumperings are self-evident. In practice all the bank contacts of the eight *BC* switches are similarly jumpered, according to the pathways which each interoffice call must take.

If the call to be considered is *243*, the *A* switch will be on its number *2* bank contact, and the number *2 BC* switch will have its wipers resting on its fourth level, and the third pair of contacts. When ready to translate and send, the sender sequence switch will move one step, thus grounding all the lower wipers of the *BC* switches. Only the lower wiper of the number *2* switch is connected—the others are normal and open. This move of the sequence switch starts the sender which performs as described in connection with Figure 10 and cuts off when three impulses have been sent. Then the sequence switch Figure 11 will move to its next contact, switching the ground to the upper wiper, and start the sender on its next round.

The performance is similar for any other decimal equivalent.

In the actual case of four wipers for each *BC* switch, the sender can send four digits in the directive. The maximum number of digits in the directive fixes the number of wipers needed.

It is the ability to move to a desired position any reasonable number of wipers that gives to the Director the possibility of sending out almost any kind of directive, one digit for each wiper which has been set. If the office code has only one digit, and the directive might have as many as four digits, a minor switch (rotary motion only) with four wipers can do it. If the office code has two digits, a Strowger switch (two motions, up and around) will serve, with as many wipers as the largest number of digits in the directive. For the usual three digit office code, a minor switch for the *A* digit and a Strowger switch for the *B* and *C* digits will serve, the Strowger switch having as many wipers as the largest number of digits in the directive.

To see how the call numbers are controlled and coordinated in sending out the directive, assume a call number *324-5342*. According to Figure 4 the first digit has rotated the *A* register three steps, the next two digits have lifted the wipers of the *BC* register two steps and rotated them to the number *4* set of bank contacts. Further, the dialing of the terminal number has set the wipers at contacts *5-3-4-2* respectively, as shown in Figure 12.

Assume that to reach the distant office the Director must send the digits *4* and *1*. The bank contacts of the *BC* switch had been cross-connected to the decimal terminals *4* and *1*, on the *IDF* (at the time of installation).

Thus there is in the register bank multiple a complete representation of the digits which are to be sent, and the bank of the sender switch carries this bank multiple with the wires in numerical order. The sender is ready to obey the indications thus presented.

There is one exception, the skip digits. Because the decimal equivalent *324* of the office code requires only a 2-digit directive, the upper pair of wipers on the *BC* switch are not needed. They are cross-connected on the *IDF* to two contacts on the bank of the *R* wiper of the sender sequence switch. As described later, this causes the sequence switch to pass by those wipers quickly without waiting for any impulse sending.

Sending the Impulses. Just as was illustrated by Figure 10, the number of impulses sent in each digit can be governed by means of a grounded contact on the bank of a register. Figure 12 shows all eight wipers, four in the *BC* register and four registers for the line number. The ground is to be placed on those wipers in succession, by means of wiper *S* of the sender sequence switch. Each time that the sequence switch advances and thus grounds a new wiper, it starts the

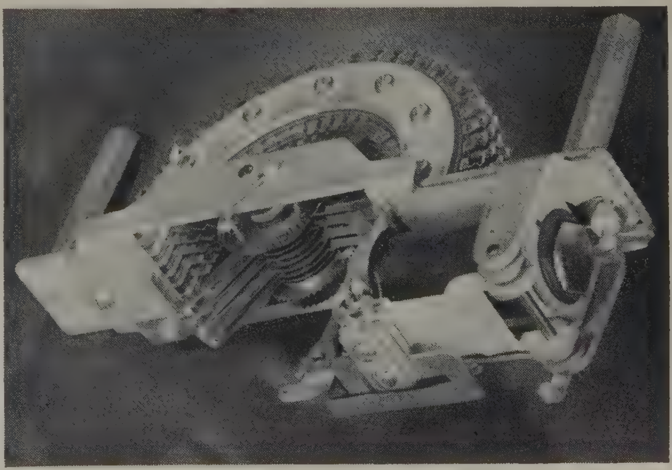


Figure 9. Rotary switch

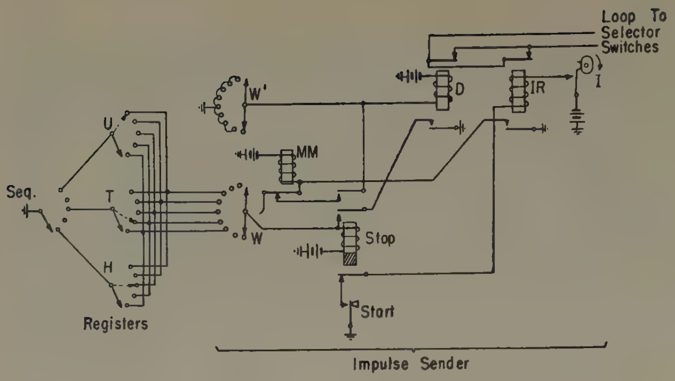


Figure 10. Register to sender relationship

sender on a round of exploration by means of the "start sender" wire. When the sender switch has made a cycle and returned to the home contact, it advances the sequence switch by means of the sequence wire.

To avoid too much complexity I have omitted from Figure 12 all the details which could be spared, trying to leave only those which will make clear how translation of the office code and the sending of impulse digits are done.

The *BC* register is controlled by the calling subscriber through a line relay *LR* in the trunk repeater. Assume that the wipers of the *BC* switch have been lifted by the second digit. As the line relay repeats the impulses sent by the subscriber, the rotary magnet *RM* steps the wipers around. At the same time the series relay *Se* pulls up and remains operated. It operates relay *F*, which locks to a ground in the trunk repeater. When the third digit ends, *Se* releases and grounds the start wire for the sequence switch. Wiper *R* connected to the self-vibrating contact of the motor magnet *MM-1*, which promptly advances the sequence switch wipers one step. This put the *S* ground on wiper number *1* of the *BC* switch, and at wiper *SW* the same start wire ground is applied to the impulse relay *IR* of the sender. As was described for Figure 10 the interrupter *I* acting through *IR* (Figure 12) steps the sender switch around to contact *4*, having thus sent *4* impulses over the loop to the first selector.

At the beginning of impulsing, relay *D* pulled up to clear the loop for *IR*, and also pulled up *MM-1* of the sequence switch, holding it operated while the sender is operating.

Having sent the four impulses, the sender switch rotates around to its home position, both bank contacts of which are open. Relay *D* releases and thus releases the motor magnet *MM-1* of the sequence switch, and advances its wipers to the next set of contacts. Here the *S* ground is placed on wiper number *2* of the *BC* switch and the sender started again, this time sending only one impulse.

Wiper *SW* has been the means for starting the sender. Its next two contacts are open, but the corresponding contacts of wiper *R* have skip wires, leading to the bank contacts of the *BC* switch which are occupied by wipers *3* and *4*. Hence the ground applied by wiper *S* operates to cause the motor magnet *MM-1* to rotate wiper *S* (and all the others) quickly past wipers *3* and *4* without sending any impulses to the loop.

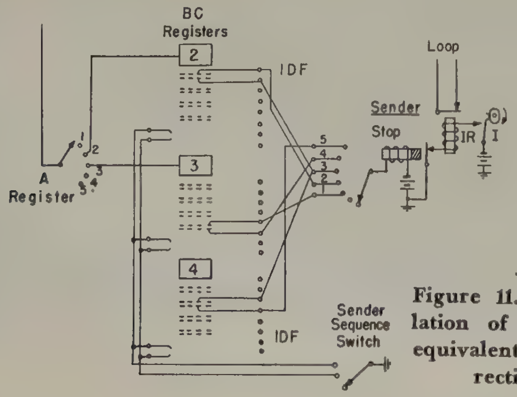


Figure 11. Translation of decimal equivalent into directive

Placing the start wire of the sequence switch into the control of the *BC* switch is to insure that the subscriber has dialed all of the office code. The directive cannot be specified until all the code digits are registered. But after that time, the directive can be sent, without waiting for the registry of the line number.

But the terminal number, though sent out as received, cannot be sent until it is received. For this reason, the starting of the sender is now changed to off normal springs *ONS* on the line registers. When any one of them is dialed away from its normal position, the *ONS* grounds a wire leading to the bank of the wiper *SW*. Thus the sender can send each digit in succession as fast as it is registered.

Holding Circuits and Release. During the registering of the call number and the sending of the directive, ten switches are held, either passively or actively. The holding circuits for these are shown in Figure 13. In the upper left corner are the line relay *LR* and the associated slow relay *6*, both of which are located in the trunk between the incoming line and the first selector. The slow relay holds the trunk from releasing, even while *LR* is impulsing into the Director.

The main holding circuit passes from the slow relay *6* to the finder switch, thence through the register sequence switch, the code *A* register, ending in the *BC* register switch. In the finder switch, relay *9* is holding the connection through its wipers, in the *BC* switch relay *11* is withholding ground from the release magnet. The *10* relay in the register sequence switch is controlling the release of six switches: the sequence switch, the *A* register, and the four line registers, *Th*, *H*, *T*, and *U*. In addition it is in a position to ground the *W-3* bank of the sender sequence switch to chase it home.

In Figure 13 the means also may be noted for switching the subscriber line through to the selectors and thus to the called telephone. Relay *7* is the through-switching relay in the trunk circuit. It is connected, through the finder switch, to the sender and the sender sequence switch as shown.

As soon as the sender reaches home from sending the last digit of the call number, relay *D* of the sender (Figure 12) falls back quickly, but the stop relay hangs on for a moment. The release of *D* permits the sender sequence motor magnet *MM-1* to release, which quickly snaps the wipers to their contacts *S*. This (Figure 13) completes the path between the ground at the stop relay through bank and wiper *W-2*, again through the sender circuit, the finder switch, to the switching relay *7* in the trunk circuit. Then the stop relay of the sender falls back.

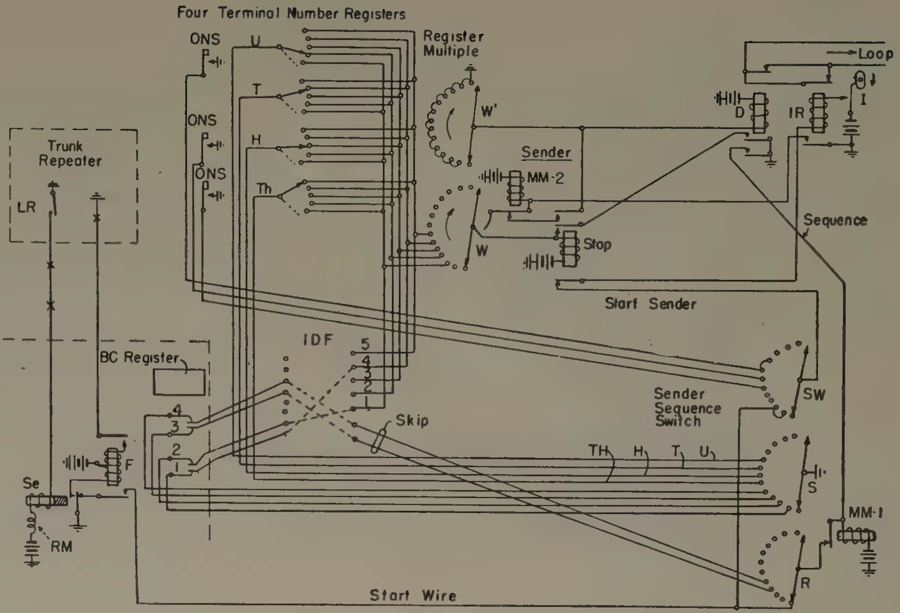


Figure 12. Registers and sender details, assembled

The switching through of the telephone to the train of switches has cut off line relay *LR* of the trunk, so that it and the slow relay *6* release. This takes the control trunk ground from the entire system of five relays, affecting seven release magnets. Relay *9* severs the finder switch connection, relay *11* operates the release magnet for the *BC* switch, relay *10* of the register sequence switch operates the release magnet of the *A* register, and all four of the release magnet of the line registers. In each such case, the release magnet is cut off by an off normal spring, which breaks its circuit when the switch reaches normal. Another ground contact on relay *10* grounds the bank of wiper *W-3* of the sender sequence switch, whereupon the motor magnet *MM-1* interrupts its own circuit and steps all its wipers around to the home position.

The Director is now ready to care for another call.

In spite of the many words which I have used in the foregoing explanation, the entire release time is very short, usually not more than one-half to one second.

THE LATER DIRECTOR

From time to time, improvements have been made in the Director. Out of them have come some very interesting structures of circuits resulting in economy of apparatus and greater flexibility. In the arrangement which I now will describe, part of the apparatus is common to a number of Directors, being released as soon as its work has been done.

In Figure 14 the telephone *Telo* is connected through non-numerical switches *Non* to an idle first selector. Out of the associated relays come several wires to a Director hunter by means of which an idle Director is found and seized.

At the right are the registers in which is to be stored the information which shall guide the sender in sending groups of impulses to the train of numerical switches leading to the distant office and subscriber line.

The dialed impulses pass through a relay *A1*, which repeats them to the magnets of the registers. There is a series slow relay which pulls up on the first impulse, remains energized, and after the digit is registered, releases and causes the register sequence switch *Reg Seq* to advance one step. Three office code digits are followed by the line number, which the register sequence switch delivers to the motor magnets of the four line registers in succession. The wiper and bank marked *Reg Seq* have wiper *U* on the same shaft. During the latter part of its rotation, this switch acts as the units register of the line number.

The storage relays with their sequence switch will handle the directive and later will feed it into the decimal multiple.

Below the dashed line are four sets of apparatus which are common to as large a number of Directors as the traffic needs. First is the *A* register hunter which finds and seizes an idle *A* register. This is a Strowger switch, whose vertical motion registers the *A* digit of the office code. Its wipers then rotate to find an idle *BC* register. The latter responds to the *B* and *C* digits of the office code, and connects the circuits to the translator *Trans* which is associated with it for that particular set of bank contacts.

The dialing of the terminal number is now switched to the magnets of the registers, *Th*, *H*, *T*, and *U*.

Upon completion of dialing the *ABC* digits, the translator at once sends back through other wipers of the *BC* and the *A* registers the complete designation of the directive which will guide the call to the desired office and line. This directive is delivered to the storage sequence switch four wipers, which guides each digit to its group (four relays each) where

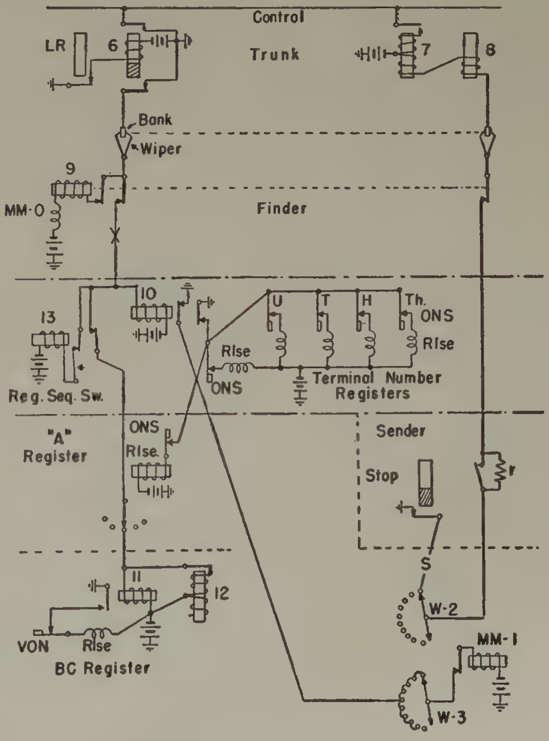


Figure 13. Release circuits

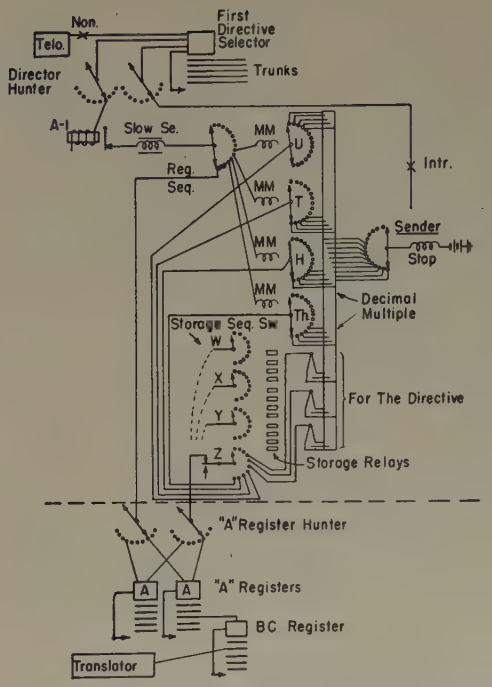


Figure 14. Improved Director, general plan

it is held by the locking up of the relays which were energized. The output contacts of each group of four relays are represented by a delta-shaped symbol at the right of each, which lead into the common decimal multiple cable. The directive may have few or many digits.

The result is that we have connected to the decimal multiple a number of settings equal to the four terminal digits and to the number of digits in the directive.

Now the apparatus below the dashed line may be disconnected, being needed no longer for the call which we are considering.

The sequence switch associated with the storage relays now takes control, connects a ground on the first directive setting, and starts the sender. The latter sends impulses into the loop leading to the first directive selector, which stops when the wiper arrives at the grounded contact. The stop relay ends the impulses and causes its sender sequence switch to influence the storage relays to ground the next directive setting. It results in the next directive being sent, with the number of impulses indicated by the existing ground on the decimal multiple. In the same way all the rest of the directive digits are sent.

In like manner the terminal registers control the impulses in its digit, until the entire number has been transmitted. At this moment, the wipers of the connector in the distant office are resting on the contacts of the called line. The events which follow are common knowledge.

Translation and Storage. The circuit device which forms the foundation is illustrated by Figure 15. Consider the four relays at the right and their contacts, mostly arranged in series with each other. If all four are energized, there is no path from the grounded spring to the sender bank. If all four relays are normal, there is a path from the grounded spring to the skip wire, which leads to that bank of the storage sequence switch to whose wiper the motor magnet is attached by its self-vibrating contact. It enables fewer directive digits to be used than the maximum provided.

Now consider the three relays at the left, and their contacts. Each relay has four main springs, one for each of the relays at the right. But the main springs are grounded according to a plan. If the key *M* is pressed, relay *M* would ground and operate relays *W* and *Y* at the right. Now trace the path from the main spring of relay *W* downward to the sender bank—the number *3* contact is grounded. Hence, if the sender moves its wipers as usual, the stop relay will pull up when the wiper reaches number *3*.

Notice that the transfer of information is practically instantaneous—the storage relays pull down together.

If the *N* key had been pressed, it would have grounded contact number *2* on the sender bank. Likewise the *O* key would have grounded the number *8* contact. Thus by pressing any key the sender can be caused to send a certain number of impulses before being stopped. Reference to Figure 7 will recall the action.

The complete code is

Relays operated...	*W*	*WX*	*WY*	*WZ*	*X*	*XY*	*XZ*	*Y*	*YZ*	*Z*
Digit produced...	1	2	3	4	5	6	7	8	9	0 or 10

It will be observed that the four wires between the *MNO* relays and the *WXYZ* relays are few enough to permit much switching without too many wipers. This is needed, for these four wires must be carried back (Figure 14) through the banks and wipers of the *BC* register, the *A* register, the *A* register hunter to the storage relays which feed into the decimal multiple into which the sender bank is wired.

The essentials of the transfer of a translation to the storage relays are shown in Figure 16. I am assuming that the directive has only three digits, *M*, *N*, and *O*, represented by the relays at the left. Beside their operating contacts, each of them has four main springs, corresponding to the four wires, *W*, *X*, *Y*, and *Z*—the basis of the transfer code.

At the right are the storage relays, three groups of four relays each. Each group, such as the *M* group, has four relays, *W*, *X*, *Y* and

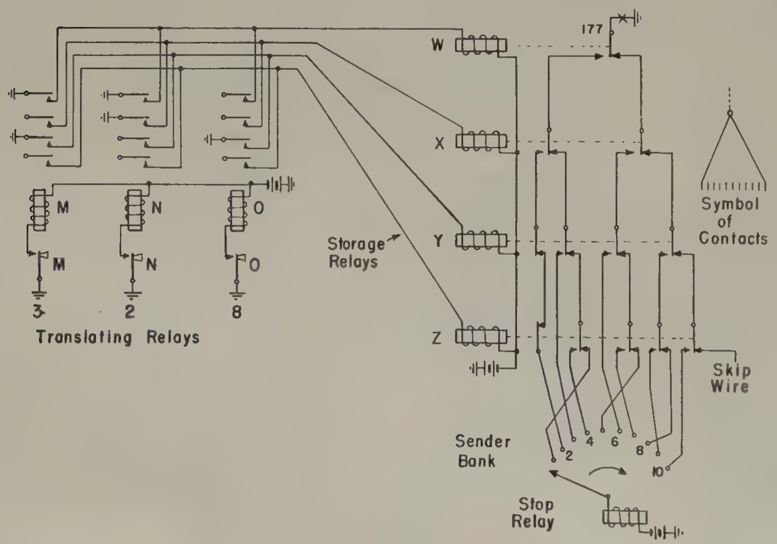
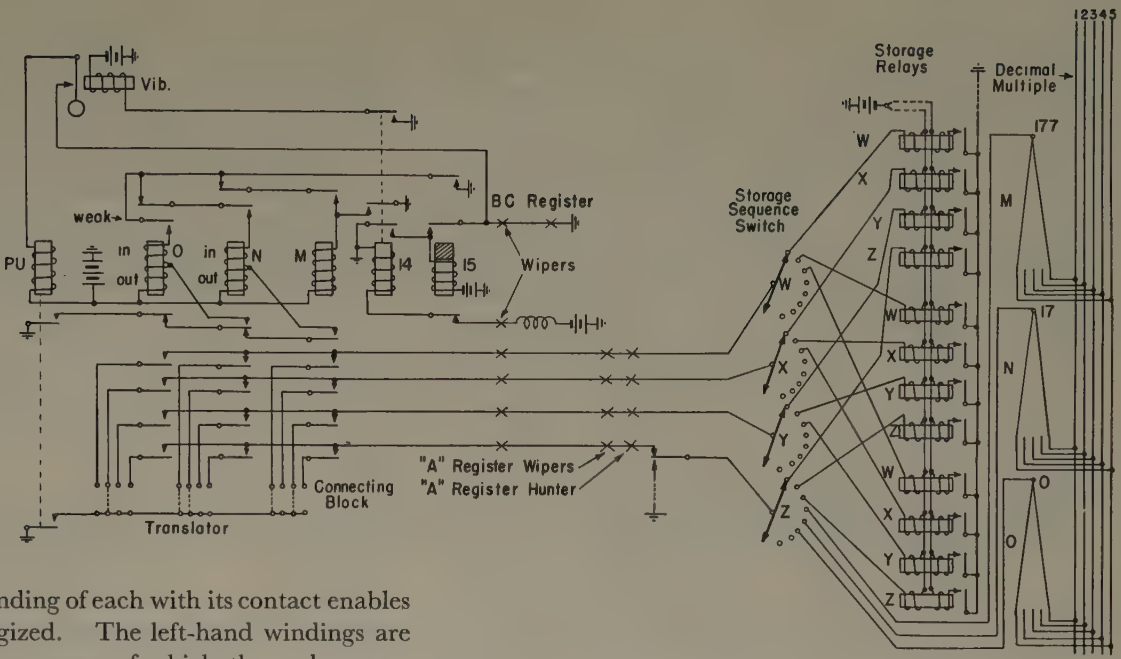


Figure 15. Translation and storage, general principles

Figure 16. From translator through storage into decimal multiple



Z. The right-hand winding of each with its contact enables each to lock itself energized. The left-hand windings are the pull-up windings, by means of which the codes coming from the translator will operate such storage relays in each group as the desired decimal digit requires. It is the storage sequence switch which delivers the code for each digit to its own group of relays.

In the translator, the three relays *M*, *N*, and *O* must be caused to operate and release in sequence, so that each may ground the desired wires. At the bottom I have shown a small connecting block, by means of which the four main springs of each relay may be wired to the ground bus bar to make the code. For instance, suppose that the necessary directive is *325*. Thus when relay *M* pulls up, it must ground wires *W* and *Y*, shown by the dotted line on the block. Likewise, relay *N* momentarily will ground the *W* and *X* wires. Then relay *O* momentarily will ground the *X* wire alone.

By a control circuit not shown, the storage sequence relay will step its wipers along. When relay *M* is pulled up, the wipers of the sequence switch will be resting on their first contacts, leading to the four storage relays in the *M* group. Hence only relays *W* and *Y* will be pulled up and lock. The contacts represented by the delta-shaped symbol (Figure 15) will connect spring *m* to wire *3* in the decimal multiple.

When relay *N* in the translator (Figure 16) is taking its turn, the wipers of the sequence switch will be resting on their second contacts, leading to the relays in the *N* group. Thus relays *W* and *X* will operate and lock. When relay *O* in the translator takes its turn, the sequence switch will guide the ground connection to relay *X* in the *O* group, storage.

The sequence operation of the *M*, *N*, *O* relays in the translator is accomplished as follows. When the *BC* register stopped its wipers on the set of contacts, relay *14* pulls up in series with a relay in the *BC* switch. Relay *14* pulls the armature of the vibrator *Vib* and holds it there, operates relay *M*, and pulls up relay *15*. The latter locks itself, grounds the holding circuit for relay *M*, and cuts off relay *14*. On falling back, relay *14* releases the vibrator armature, which, being weighted, swings back and forth like a pendulum. Its first swing to the left pulls up relay *PU*, which grounds the translator block bus bar and energizes the weak winding of relay *N*. Relays *M*, *N*, and *O* are of the 2-step type. Hence, relay *N* closes only its weak contact. When the vibrator causes *PU* to release, the short circuit is removed from the *in* winding of relay *N*, which promptly operates and locks itself to the ground on relay *15*. Relay *M* falls back and the code wires are grounded by relay *N*.

The same operations take place during the next closure of the vibrator, operating relay *O* and releasing relay *N*. This permits the *O* relay to have its chance at the code wires.

The last digit of the directive thus having been stored, the circuits are cut off at the sequence switch, so that the *A* register, *BC* register, and translator are released and return to normal, ready to be seized by another call.

In the storage sequence switch, the *Z* wiper is switched to a circuit where it gets ground. From here this part acts like a sender sequence switch, working with the sender (Figure 14) in applying ground to each of the directive springs *m*, *n*, and *o* in turn, and afterward to the wipers of the line register *Th*, *H*, *T*, and *U* in succession.

Incidental Functions and Services. Not all calls go through with the regularity which I have assumed. Some of the following incidentals must be expected:

1. The subscriber removes the handset but does not dial.
2. He dials only part of the call number and then stops.
3. He dials a nonexisting office.
4. He dials a dead line number.

There is not room here to describe all these details, but adequate means have been provided. The first two are handled by a slow time device, which comes into play if any Director is held longer than a set limit, after which the connection is released. The third is run off to an information desk. The fourth is handled on the banks of the connectors as now done in automatic exchanges.

Trunking to manual offices, which have call indicators to display the number in front of the operators is handled by inserting a coder in the trunk beyond the first selector, or a later selector. This changes the decimal digits into the kind of code used and sends it to the manual switchboard. Thus it does not affect the structure of the Director. Incoming calls from manual to automatic are sent by the operator using some kind of calling device, either the push-button type or the dial type (for small manual boards). Such calls go directly into the automatic switches—the Director is not involved.

Enough has been illustrated and described to show rather conclusively that some kind of translating device can be made which will pickout, from any office code, any prescribed decimal number, and that this reliably can control an impulse sending device. Communication engineering is especially rich in devices and combinations. These being true, we need not care very much how the interoffice selectors are arranged, or how the multioffice exchange is laid out. We can make the complete Director assembly do whatever is necessary to direct a call to the desired distant office and to connect with the desired telephone.

Standards for Turbine-Generators

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AIEE Standards 601 and 602, covering large 3,600-rpm condensing steam turbine-generators, were adopted officially in February 1945. Now, after three years of trial use, a review has been made to determine the manufacturers' progress in developing the units and the degree of acceptance on the part of the electrical utility industry, and the results have been tabulated.

THE REPORT of the joint AIEE-American Society of Mechanical Engineers committee on preferred Standards for large 3,600-rpm 3-phase 60-cycle condensing turbine-generators was made available to the AIEE Standards committee in October 1944, and later was presented under the sponsorship of the AIEE power generation committee as technical paper 45-36 at the 1945 AIEE winter meeting in New York, N. Y.

AIEE Standard 601 covering the "Joint AIEE-ASME Preferred Standards for Large 3,600-Rpm Condensing Steam Turbine-Generators," was approved by the ASME council, February 23, 1945, and by the AIEE board of directors, February 27, 1945. The companion AIEE Standard 602 covering "Standard Specification Data for Generators for Large 3,600-Rpm Condensing Steam Turbines" was approved by the AIEE board of directors, February 27, 1945.

Table I gives the ratings and characteristics of the six units covered by the preferred Standards.

Approximately three years' time has elapsed since the Standards were adopted officially for trial use, and it is now appropriate that a review be made to check the progress made by the manufacturers in developing and building the units, and the degree of acceptance of the program by the electrical utility industry. This progress report is restricted to the scope of the AIEE portion of the joint committee, although the data submitted cover the complete turbine-generator units. The adoption of the Standards came at an unfavorable time when industry was in the process of converting from a wartime to a peacetime program. The development of the six new standard turbine-generator units necessitated the making of engineering designs, manufacturing and customer approval drawings, manufacturing tools, and assembly equipment. The drafting load involved in producing drawings for the generators only, represented 3,000 to 4,000 man-days work. The manufacturers were faced further with another unfavorable situation—a shortage of both experienced and inexperienced draftsmen, design engineers, and manufacturing engineers.

Coupled with an unsettled economic situation with attendant strikes and other disturbing factors, there was an increasing need by the utility industry for the purchase and delivery of more and more steam-driven turbine-generator

Table I. Preferred Standards for Large 3,600-Rpm 3-Phase 60-Cycle Condensing Steam Turbine-Generator

	Air-Cooled Generator		Hydrogen-Cooled Generator Rated for 0.5 Pound Per Square Inch Hydrogen Pressure			
Turbine-generator rating, kw	11,500	15,000	20,000	30,000	40,000	60,000
Turbine capability, kw	12,650	16,500	22,000	33,000	44,000	66,000
Generator rating, kva	13,529	17,647	23,529	35,294	47,058	70,588
power factor	0.85	0.85	0.85	0.85	0.85	0.85
short-circuit ratio	0.8	0.8	0.8	0.8	0.8	0.8
			Hydrogen-Cooled Generator Operated at 15 Pounds Per Square Inch Hydrogen Pressure			
Generator capability at 0.85 power factor, kva			27,058	40,588	54,117	81,176

Full text of paper **48-110**, "Progress Report on AIEE-ASME Standard Large 3,600-Rpm Turbine-Generators," presented at the AIEE Great Lakes District meeting, Des Moines, Iowa, April 1-3, 1948, and scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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units to meet rapidly increasing loads. Both manufacturer and purchaser were faced with the desire, on the one hand, to use the old type units which already were developed and defer the development of the new units, and, on the other hand, to carry through both programs simultaneously. All manufacturers recognized that in many other respects this was an ideal time to introduce the new standard line and that any appreciable delay in the development of the new ratings seriously would jeopardize the over-all acceptance of the program, and thus it was decided to develop the new standard ratings as quickly as possible.

Table II. Customer Orders Obtained by the General Electric Company for Preferred Standard Ratings Up to December 1, 1947

Kw Ratings	Number of Units	Total Kw Capacity
11,500	4	46,000
15,000	0	
20,000	6	120,000
30,000	9	270,000
40,000	20	800,000
60,000	21	1,260,000
Total	60	2,496,000*

* The number of units and total kilowatt capacity represents approximately one-third of the General Electric turbine-generator business in sizes of 10,000 kw and larger.

At present there are four manufacturing companies in the United States which are interested in building these standard units. Three are concerned with all ratings and one is concerned only with the smaller ratings. The accompanying tables show the progress made by the different manufacturing companies and the purchaser acceptance of the new standard line.

Table III. Customer Orders Obtained by Westinghouse Electric Corporation for Preferred Standard Ratings Up to December 1, 1947

Kw Ratings	Number of Units	Total Kw Capacity
11,500	1	11,500
15,000	0	
20,000	3	60,000
30,000	23	690,000
40,000	10	400,000
60,000	19	1,140,000
Total	56	2,301,500*

* The total kilowatt capacity represents approximately 48 per cent of the Westinghouse Electric Corporation's turbine-generator business in sizes of 10,000 kw and larger.

Several of the new line units have been built and shipped and are now either in operation or being erected. On the basis of the data and the general situation associated with the production of the new standard line, the following observations and conclusions can be made.

1. All of the standard line units are now available with the exception of the 15,000-kw rating.

2. The purchaser acceptance has been wide, and the number of units and total kilovolt-amperes now on order represent 35 to 40 per cent of the total turbine-generator business for units of 10,000-kw rating and above.

3. In 1948 and thereafter, it is anticipated that orders placed for new units will be almost exclusively of the new standard line for the range of ratings covered by this line. It is expected that this will represent approximately 50 per cent of the current turbine-generator business in that period.

4. With the development of the standard line practically complete, the manufacturer can furnish outline and customer approval drawings at the time the negotiation proposals are presented. After the purchase order is placed, both the manufacturer and the purchaser can place orders immediately for manufacturing and construction materials. The purchaser thus is assured definitely of a better product, at reduced cost, and with faster deliveries.

From comments and suggestions received from both purchaser and manufacturer groups, it is recommended that the existing AIEE committee again become active and consider the following items:

1. Reconsider the 15,000-kw unit and decide whether or not this rating should be designed for hydrogen cooling and have the same characteristics as the four larger ratings.

2. Review the "Standard Specification Data for Generators for Large 3,600-Rpm Condensing Steam Turbines" for major changes, modifications, and additions.

3. Consider the advisability of standardizing the next larger 3,600-rpm hydrogen-cooled unit which is being purchased in appreciable numbers for ratings of 80,000 and 90,000 kw and appropriate power factor and short-circuit ratio values.

Table IV. Customer Orders Obtained by Allis-Chalmers Company for Preferred Standard Ratings Up to December 1, 1947

Kw Ratings	Number of Units	Total Kw Capacity
11,500	2	23,000
15,000		
20,000	5	100,000
30,000	2	60,000
40,000	7	280,000
60,000	0	
Total	16	463,000*

* This represents approximately 40 to 50 per cent of Allis-Chalmers turbine-generator business under construction in sizes of 10 kw and above.

In terms of machines in the same size range, the percentage of standardized units is somewhat higher, and has been increasing steadily. During the second half of 1947 about 75 per cent of the units sold within this band were of the standardized design.

Table V. Customer Orders Obtained by the Elliott Company for Preferred Standard Ratings Up to December 1, 1947

Kw Ratings	Number of Units	Total Kw Capacity
11,500	1	11,500
15,000	0	
20,000	0	
30,000	0	
40,000	0	
60,000	0	
Total	1	11,500*

* The total kilowatt capacity represents approximately 10 per cent of the Elliott turbine-generator business in sizes of 10,000 kw and larger.

Table VI. Customer Orders Obtained by All Manufacturing Companies for Preferred Standard Ratings Up to December 1, 1947

Kw Ratings	Elliott Kw	Allis-Chalmers Kw	Westinghouse Kw	General Electric Kw	Total Kw
11,500	11,500	23,000	11,500	46,000	92,000
15,000					
20,000		100,000	60,000	120,000	280,000
30,000		60,000	690,000	270,000	1,020,000
40,000		280,000	400,000	800,000	1,480,000
60,000			1,140,000	1,260,000	2,400,000
Total	11,500	463,000	2,301,500	2,496,000	5,272,000

The Locomotive Traction Generator Comes of Age

RICHARD LAMBORN
ASSOCIATE AIEE

MORE THAN 2,100,000 horsepower of Diesel-electric locomotives was produced in the United States during 1947. These and other internal power locomotives, including steam-turbine electric and motor-generator locomotives, all incorporate d-c traction generators of specialized design. Taken together, they account for the surprising figure of 70 per cent of the total d-c generator production of the entire United States for the year.

For a generator which is to be applied to locomotive service, small physical size (especially minimum over-all length) and light weight are items of paramount importance. Hence, traction generators are characterized by having a relatively large number of poles for their capacity, using only class *B* forms of insulation, being very closely coupled to their prime movers, and by having a single bearing of antifriction type at their commutator end.

Railroading requires the development of high power outputs over a wide range of operating speeds. This is equivalent to a widely variable torque demand as contrasted with the fundamentally constant torque available from a Diesel engine operating at rated power output. It is the flexibility and reliability with which electric drive can provide the required variation and multiplication in torque between the prime mover and the driving axles that account for the phenomenal growth of this branch of the electrical industry.

To provide torque range in the d-c transmission system, the traction generators are equipped with a means whereby their excitation is regulated automatically to make them deliver full kilowatt output at high voltage and low current as well as at low voltage and high current, as indicated in Figure 1. The range of volts and amperes over which such a machine must operate continuously becomes an important factor in determining its size. So much so, in fact, that expressing capacity in terms of maximum rated volts times maximum rated amperes per 1,000 or "kilovolt-amperes" (as they do not occur simultaneously) defines the electrical size of a traction generator much more accurately than stating the rating in terms of kilowatts.

Factors such as horsepower per ton on drivers, maximum locomotive speed at which full power is developed, traction motor characteristics, and traction motor control connections or combinations used, each plays an important part in determining the generator "kilovolt-ampere" requirement. Thus, the manner and the understanding with which the design and application engineers co-ordinate these aspects of the problem may prove just as important in determining the size of generator supplied for any given job as the more familiar elements of prime mover horsepower and speed.

For locomotives applied in main line road service, the continuous "kilovolt-ampere" rating usually will be from 1.8 to 1.5 times greater than the kilowatt rating. Generators applied on switching or industrial types of locomotives may not require so much spread between the continuous kilovolt-ampere and kilowatt ratings because of the low load factor that normally results from their on-and-off type of operation.

Traction generator design also is affected to some extent by the type of excitation system which is used to obtain the required constant horsepower or equilateral hyperbola type of volt-ampere output characteristic. Self-excited generators with simple stalling control such as often are applied on small capacity power plants must be designed to operate at comparatively low saturation. Generators incorporating self, separate, and differential series field windings, with governor servo-operated rheostat in the separate excitation winding to eliminate engine stalling, obviously require a relatively heavy stator structure. Among systems requiring separate exciters, those using an amplidyne incorporate definite overload and overexcitation protection, permitting the designer to use the minimum of material in the main generator stator parts.

Although relatively a newcomer in the 60-year-old electric-traction industry, the 22-year-old locomotive traction generator has assumed a role of major importance. Business in these generators in 1948 promises to exceed that of 1947, with a probable production of 2,500,000 horsepower. There has been striking progress in design through the years and the future holds promise of a continuing trend toward higher speed, higher horsepower, and still more output per pound or per cubic foot.

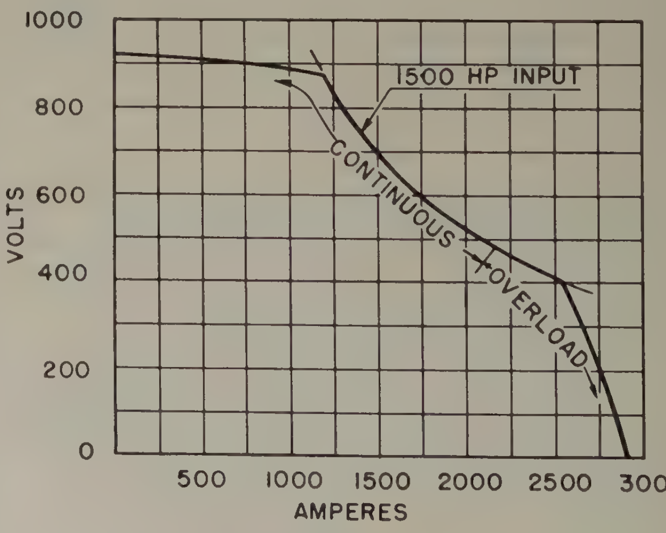

Figure 1. Locomotive traction generator volt-ampere output characteristic

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Digest of paper **48-116**, "The Locomotive Traction Generator Comes of Age," recommended by the AIEE land transportation committee and approved by the AIEE technical program committee for presentation at the AIEE summer general meeting, Mexico, Federal District, Mexico, June 21–25, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Automatic Pilots

J. C. OWEN

The application of servomechanisms to airplane control started with short-time pilot relief systems which would keep the aircraft on its already established course. As more and more operations could be performed by the automatic pilot, the idea evolved of obtaining complete flight path control from take-off to landing. This will open the way for faster flights and remote control of guided missiles.

THE definition of an automatic pilot depends a good deal upon point of view. Operationally it might be defined as a device for relieving, aiding, or supplanting the human pilot in flying an airplane. Technically a complete automatic pilot is a multiple system of complex servomechanisms for stabilizing an aircraft about its center of gravity while in flight and for controlling it to a predetermined flight path.

It is of interest to note that the first airplane to fly under the control of an automatic pilot did so in 1909. It is an equally surprising revelation to read the related literature of the time and find how advanced were the ideas concerning automatic pilots. Their strategic, economic, and physiological values were quite accurately projected. As all airplanes of that day were fugitives from the laws of aerodynamics, early automatic pilot work was hampered seriously by their dubious and sometimes erratic response. The large size and weight of automatic pilot components relative to the size and load carrying capacities of the ships were other detrimental factors. However, soon after World War I, aircraft design began to improve rapidly and automatic pilot design followed a close second.

The earliest concepts of an automatic pilot embraced the idea of pilot relief—a device to afford short periods of respite to the pilot to alleviate fatigue. As design techniques improved, the periods of relief became longer and longer, and the mechanism required less and less of the pilot's attention. Although the idea of an automatic pilot being merely a relief device long since has disappeared in the minds of designers, that concept still persists in some operational quarters. The basic design problem of a relief automatic pilot is that of stabilizing the aircraft about its center of gravity. This is also the primary design problem of any automatic pilot, as wills be shown by an examination of some of the fundamentals involved.

An airplane in flight is a free body in space having six degrees of freedom, three rotational and three translational (Figure 1). This freedom is considered to occur about three axes, mutually at right angles to each other intersecting at the center of gravity of the aircraft. Rotation in bank occurs about the longitudinal or X axis and is controlled by the ailerons; rotation in pitch occurs about the lateral or Y axis and is controlled by the elevator; rotation in yaw occurs about the vertical or Z axis and is controlled by the rudder. Translation in the forward direction occurs along the X axis, in the lateral direction along the Y axis, and in the vertical direction along the Z axis.

When a control surface is deflected, an aerodynamic force is created because of the passage of the slipstream over the surface and its associated structural member. The force thus created is, for small angles, usually proportional to angular surface deflection and is considered to be centered at a point in or near the surface. It operates on the aircraft through a moment arm whose length is the distance between this point and the center of gravity of the ship. This moment is called a control moment and is, in general, proportional to deflection. A control moment imparts rotational acceleration to the ship about the respective axis. By manipulating the control surfaces manually from the cockpit, the pilot is thereby able to create and employ control moments to maneuver his airplane as he desires.

From this we conclude that the obvious method for stabilizing an aircraft is to establish references within the ship and then to monitor the ship's relative departure from these references by means of convenient indexes (Figures 2 and 3). When departure occurs, as shown by the indexes, corresponding control properly applied will return the ship to the predetermined flight attitude. This is exactly what a pilot does manually in pitch and roll when using an artificial horizon under instrument flight conditions (Figure 4). He employs the same technique in yaw by utilizing a rate of turn gyroscope, or a compass, or a directional gyroscope. Therefore, if proper corrective control with respect to the references can be applied automatically, a basic or relief automatic pilot will result.

Many automatic pilots utilizing pneumatics or hydraulics have been manufactured, but the trend during the last few years has been toward electrical techniques. The prominent automatic pilots in current manufacture in the United States and England are of this type. The electric-electronic automatic pilot employs resistive or inductive signal generators on attitude and other signal sources throughout the system. The inductive generators are of the E pick-off or synchro types. The latter variously are called Autosyns, Selsyns, and so forth. Figure 5 shows some Autosyn signal generators used in automatic pilot work. The signals from these generators may be operated on by any of the normal mathematical processes and the resultant amplified to run a motor. The motor operates the control surfaces through a gear train and linkages.

Inasmuch as the control moment applied is a function

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of surface deflection, it appears highly desirable to keep track of the control surface and limit its deflection by some deliberate action. One method for accomplishing this is to generate a signal as a function of control surface deflection and employ it to oppose the input signal or signals to the amplifier. Such a system then gives a control surface deflection proportional to the input signal. This follow-up method is easily recognizable as the same technique used in feed-back amplifier design. A follow-up device is not strictly necessary from a theoretical point of view but it contributes immensely to the internal stability of the mechanism and adds greatly to the inherent safety of the automatic pilot. Without such a precaution, it would be possible for a persistent disturbance to hold the ship off reference long enough for the servomotor to wind up the control surface to catastrophic proportions. Even if the servomotor stalled before structural damage resulted, the experience could be very disquieting.

Control surface position is by no means the only type of follow-up that may be employed. Control surface force and control surface rate of rotation are two other methods which have had relatively extensive use. Each type has its advantages and disadvantages, but position follow-up has proved quite satisfactory and is in general use in automatic pilots currently manufactured.

Now, obviously, all this equipment which comprises the automatic pilot constitutes a servomechanism and can be shown in a block diagram such as Figure 6. The system represented presents a straightforward design problem readily susceptible to ordinary servomechanism analysis methods. However, the characteristics of the airplane prevent analysis and design on this basis. The automatic-pilot–control-surface system is but a subsidiary servomechanism contained within the main system of which the aircraft is the chief component.

The block diagram of the complete loop is shown in Figure 7 as it pertains to the pitch axis. Error is measured instantly by the pitch gyroscope and transmitted electrically to the amplifier which, in turn, delivers electric power. The power response is, of course, dependent upon amplifier operators and therefore exhibits the lags or oscillatory phenomena which characterize the amplifier. The servomotor transforms the electric power into mechanical power and transmits it through the ship's control cable system to the elevator. The mechanical power reflects amplifier characteristics as modified by the servomotor and shows additional characteristics as imparted by the electric and mechanical components of the servomotor. The elevator in turn operates upon the applied mechanical power in accordance with its own properties to impart a restoring control moment. The aircraft then modifies the moment to produce restoring velocity. In the meantime the servomotor output shaft position has been relayed back by the follow-up circuit to oppose the error signal so that the elevator deflection will be proportional to error.

This diagram delineates the problem and illustrates the general servomechanism relationships of the components. As a complete formal analysis would occupy a disproportionate amount of time and would cover much ground not necessarily peculiar to automatic pilots, we will confine our discussion to generalities special to the particular problem.

The power relationships of the loop are worth noting. The gyroscope signal supplies no appreciable power. The amplifier supplies a low order of power generally between 30–100 watts. The servomotor merely transforms this power from electric to mechanical, actually dissipating some in the process. The control surface is supplied with this low level power which of itself, directly applied, would have little effect upon the ship. However, the control surface, though requiring little power for its own operation, acts like the grid of an amplifying tube in that it directs and controls the application of high level power which comes ultimately from the ship's engines. We have, in effect, two amplifying systems, one electric and one mechanical. The gyroscope pick-off and electronic amplifier comprise the first and the control surface and aircraft the second, the two systems being coupled by an electromechanical transformer, the servomotor.

The satisfactory solution of the loop depends upon many factors. Fortunately a few are favorable. In the first place, thanks to the aerodynamacists, most modern airplanes possess a reasonable amount of natural stability and when properly trimmed in still air, will do a pretty fair job of flying hands off. We, therefore, do not have to start with something that is inherently unstable and erratic. In the second place, airplanes are designed so that people can fly them. This means that large amounts of power are not required and that corrective action can be relatively slow without disastrous

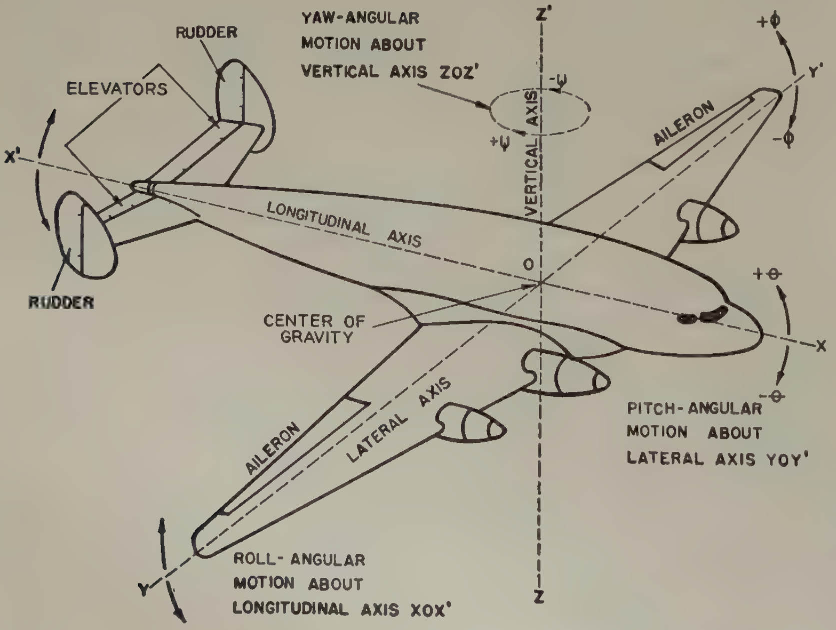


Figure 1. The six degrees of freedom

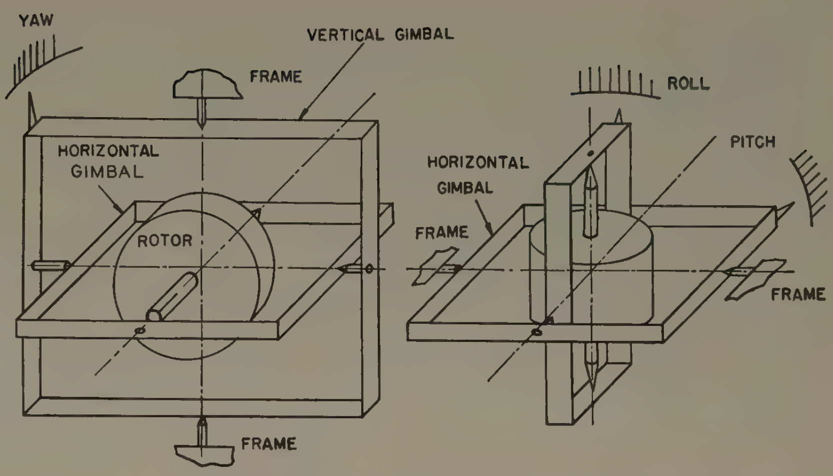


Figure 2. Directional (left) and vertical (right) gyroscopes

results. So with ordinary techniques, it is possible to obtain automatic response several times faster than human response and thereby obtain more accurate flight.

There are several methods for evaluating the aircraft for purposes of studying control. One method in particular lends itself to easy understanding and is readily susceptible to solution by ordinary mathematical tools. This method neglects translational motions and their effects and assumes the aircraft to be a simple vibrating system, free to oscillate about its center of gravity. To the strict theorist this is woefully inadequate as it neglects a multitude of factors. However, when tempered with judgment born of experience and supplemented by simulator and flight tests, this method gives admirable results. Its limitations will be discussed subsequently.

Consider the aircraft to be a simple oscillating system with viscous damping about any of its three axes, not unlike a weather vane, and assume a gust hits the ship and imparts a moment which causes angular acceleration. This angular acceleration is opposed by the inertia of the ship and aerodynamic damping about the respective axes. Additionally, in pitch and yaw, it is opposed by static stability. Inertia is, of course, self-explanatory. Damping is the opposition to rotation offered by the air, and static stability is a weathercock or spring constant characteristic. These quantities are dynamically analagous to electrical inductance, resistance, and capacitance.

If the gust moment is equated to its opposing forces, the following simplified basic equations result:

$$\text{(Roll)}\quad L_G = I_L\frac{d^2\phi}{dt^2} + D_L\frac{d\phi}{dt} \tag{1}$$

$$\text{(Pitch)}\quad M_G = I_M\frac{d^2\Theta}{dt^2} + D_M\frac{d\Theta}{dt} + S_M\Theta \tag{2}$$

$$\text{(Yaw)}\quad N_G = I_N\frac{d^2\Psi}{dt^2} + D_N\frac{d\Psi}{dt} + S_N\Psi \tag{3}$$

where L_g, M_g, N_g are the gust moments in roll, pitch, and yaw, I, D and S with subscripts the moments of inertia, damping coefficients, and static stability coefficients, all respectively. The angles of departure are ϕ, Θ, Ψ respectively. (Liberties are taken with standard National advisory Committee for Aeronautics symbols to make the significance of the coefficients more apparent to the casual reader.)

Equation 1 shows that an angular acceleration in roll first is opposed by inertia and then, as angular velocity increases, by the damping moment. Finally the damping moment equals the gust moment, acceleration ceases, and the inertia term disappears. The ship, from then on, continues to roll at a constant angular rate. Equations 2 and 3 show that angular accelerations about pitch and yaw initially are opposed, as before, by inertia and then by damping. However, constant rates of rotation do not result because the static stability moments, which increase with the first power of the angles of departure, eventually become great enough to stop motion. In general, therefore, the inertia term, initially large, decreases to pass through zero as maximum velocity is reached and then reverses sign actually to aid the gust moment, finally degenerating to zero as rotation ceases. Damping moment reaches a maximum at maximum rate of rotation, and then decreases to zero as the static stability brings the system to rest by exerting increasing opposition with increasing angles of departure. So, in pitch and yaw, a disturbing moment ultimately is opposed only by the static stability moment. The limiting angles of departure, for a given disturbance, are dependent upon these coefficients. (This discussion should not lead one to believe that the motions described consume considerable time. Normally the excursion and return are measured in fractions of a second.)

The introduction of an automatic pilot control to help restore the plane to reference the equation 2 becomes

$$M_G = I\frac{d^2\Theta}{dt^2} + D\frac{d\Theta}{dt} + S\Theta + M_c \tag{4}$$

where M_c is the control moment applied by the elevator as a result of automatic pilot response. If the gust is momentary, the airplane becomes a freely oscillating body and the balance of moments can be written:

$$I\frac{d^2\Theta}{dt^2} + D\frac{d\Theta}{dt} + S\Theta + M_c = 0 \tag{5}$$

If C is the control moment coefficient per unit of angular deflection of elevator, and β is the angular deflection of the elevator then:

$$I\frac{d^2\Theta}{dt^2} + D\frac{d\Theta}{dt} + S\Theta + C\beta = 0$$

and

$$-\frac{I\dfrac{d^2\Theta}{dt^2} + D\dfrac{d\Theta}{dt} + S\Theta = \beta}{C} \tag{6}$$

As simplification, assume that the outputs of the signal generators, amplifier, and servo-elevator system are linear with input and that their time lags are negligible compared with that of the ship. Their characteristics, therefore, may be represented by simple factors. This is permissible procedure in considering most conventional present-day aircraft. Let Θ equal the output signal of the pitch axis of the vertical gyroscope. If F is the feed-back constant, $F\beta$ is the feed-back or follow-up signal. When the system is at rest, F equals the ratio of airplane amplitude to surface amplitude. Then the net signal to the amplifier is $\Theta - F\beta$, and $\mu(\Theta - F\beta)$ is the amplifier output where μ is amplifier gain. If K is the servo-elevator constant then its output produces elevator angular velocity so that

$$K\mu(\Theta - F\beta) = \frac{d\beta}{dt} \tag{7}$$

Substituting in this equation the value for β obtained previously gives

$$K\mu\left[\Theta - F\left(-\frac{I\frac{d^2\Theta}{dt^2} + D\frac{d\Theta}{dt} + S\Theta}{C}\right)\right] = \frac{d}{dt}\left(-\frac{I\frac{d^2\Theta}{dt^2} + D\frac{d\Theta}{dt} + S\Theta}{C}\right) \tag{8}$$

Simplifying the foregoing and collecting terms,

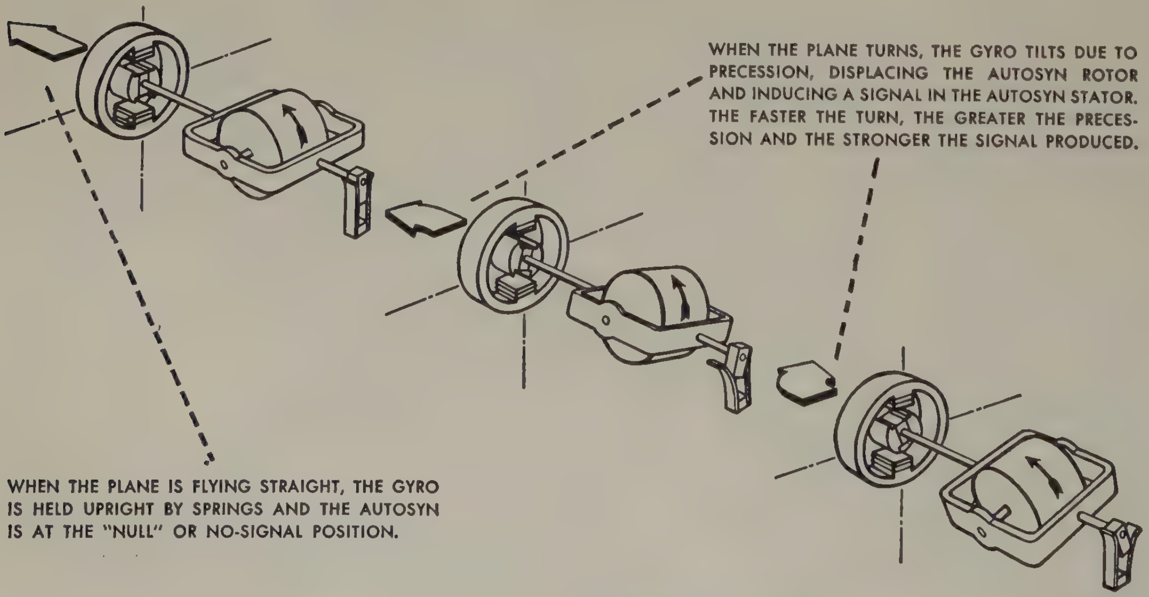
$$\frac{d^3\Theta}{dt^3} + \left(\frac{D}{I} + K\mu F\right)\frac{d\Theta}{dt^2} + \left(\frac{S + K\mu FD}{I}\right)\frac{d\Theta}{dt} + \left(\frac{K\mu FS + CK\mu}{I}\right)\Theta = 0 \tag{9}$$

which is the equation of motion of the system under displacement error control.

An examination of this equation reveals the constitution of the different parts of the error signal as contributed by the various types of motion. The $d^3\Theta/dt^3$ term, representing control surface speed, is independent of all constants and depends solely upon the character of Θ. The acceleration modifier reflects all constants except S and C, the velocity modifier all but C, and the displacement modifier all but D. The airplane constants, I, D, S, and C, are, of course, not susceptible to change by automatic pilot design. The stability and over-all performance of the system therefore depends upon the proper selection of the other constants. Although the voltage amplifier gain usually is fixed by design, the μ of the over-all amplifier can be varied by having interchangeable power amplifiers and corresponding servomotors. K is determined in part by the servomotor gear ratio and may be altered to some extent during the installation of the equipment by varying the mechanical advantage of servomotor to elevator hook up. Feed-back ratio is usually readily changeable in flight by means of potentiometers so that this becomes the final adjustment.

A word now about the limitations of the equations. As mentioned before, translatory motions are neglected and assumed to have no secondary effects, and the motion is assumed to be simple oscillatory. Furthermore, it is assumed that the three sets of axes of the incident air mass, the aircraft structure, and the gyroscopic reference are coincident or differ only by constants. It further is assumed that no aerodynamic interaction exists between axes. Therefore, these equations are precise only for infinite frequency and zero amplitude and for a rigid solution they are inadequate. Such a solution involves the six complete equations of motion which are obtained by equating all mass accelerations along each axis to the corresponding component of applied forces and equating the rates of change of moments of momentum about each axis to the appropriate applied moments. The constitution of these equations is complex and their solution difficult and onerous. Moreover, considerable compromise must be made to obtain an intelligible solution at all. Therefore, inasmuch as chiefly small angles of departure and small periods of time are being considered, and inasmuch as numerous unaccountable variables creep into the picture anyway, it appears that the less onerous method is the more practical.

Although the solutions obtained hold for only one air speed and one air density, stability ranges usually can be adjusted to cover useful air speeds and altitudes. All methods of solution have one insuperable fundamental error. They all assume the aircraft to be a rigid body. Nothing could be further from the truth. Except for fighters and the like, an airplane might be defined as a collection of assorted and sundry hardware flying in more or less close formation. They are usually a relatively flexible structure.



WHEN THE PLANE TURNS, THE GYRO TILTS DUE TO PRECESSION, DISPLACING THE AUTOSYN ROTOR AND INDUCING A SIGNAL IN THE AUTOSYN STATOR. THE FASTER THE TURN, THE GREATER THE PRECESSION AND THE STRONGER THE SIGNAL PRODUCED.

WHEN THE PLANE IS FLYING STRAIGHT, THE GYRO IS HELD UPRIGHT BY SPRINGS AND THE AUTOSYN IS AT THE "NULL" OR NO-SIGNAL POSITION.

Figure 3. The rate gyroscope

The importance of flight testing cannot be overemphasized. An automatic pilot is not completely designed until it successfully has flown numerous ships under a wide range of conditions for many many hours. Despite all its limitations and restrictions the simple vibratory method provides a sound and workable basis of analysis and is capable of producing excellent results.

Some interesting relationships of the physical forces on the airplane can be established if the control surface is assumed to follow the error signal without appreciable lag so that

$$\Theta - F\beta = 0$$

This means, of course, that instantaneously the control moment applied by the automatic pilot is a direct function of the error so that

$$I\frac{d^2\Theta}{dt^2} + D\frac{d\Theta}{dt} + S\Theta + E\Theta = 0$$

where E is the over-all automatic pilot control surface coefficient. It is obvious from this equation that proportional error control has the appearances of increasing static stability and the equation may be written

$$I\frac{d^2\Theta}{dt^2} + D\frac{d\Theta}{dt} + (S+E)\Theta = 0 \qquad (10)$$

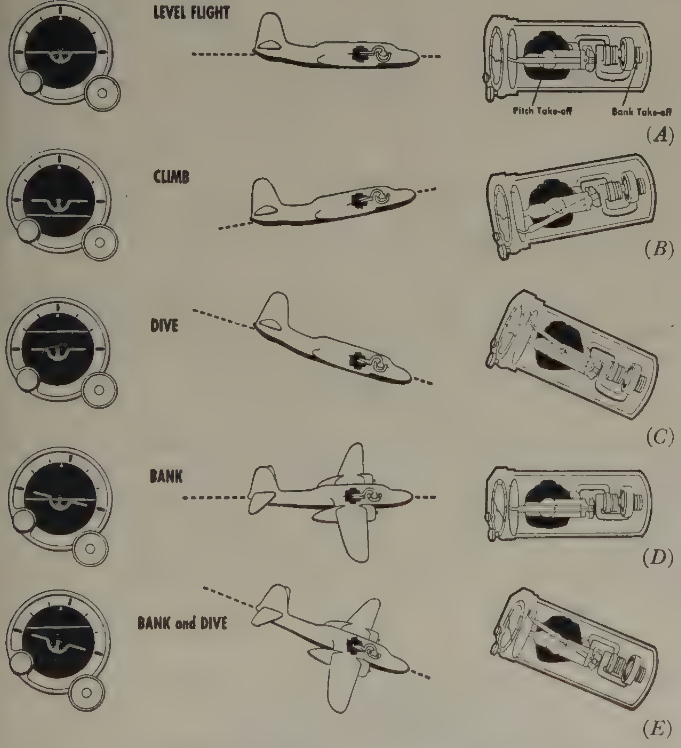


Figure 4. The use of the artificial horizon

A—The horizon bar is level, the bank indicator centered, the pitch and bank take-offs are in a central of neutral position

B—The horizon bar moves down as the airplane climbs, and the pitch take-off is turned as a result

C—The horizon bar moves up during a dive, the pitch take-off is turned in the opposite direction

D—As the airplane banks, bank indicator is moved, the bank take-off moving at the same time

E—Both the bank and the pitch take-offs are moved as the gyroscope horizon control indicated a dive and bank

Figure 5. Some Autosyn signal generators

Solving for natural frequency we obtain

$$\omega = \sqrt{\frac{S+E}{I} - \left(\frac{D}{2I}\right)^2} \qquad (11)$$

This shows that the success of error control depends largely upon the magnitude of D compared to S and I. If we desire asymptotic return to reference, in other words critical damping, then

$$\frac{S+E}{I} = \left(\frac{D}{2I}\right)^2 \qquad (12)$$

If D is small or E too large as a result of too much control and $(S+E/I) > (D/2I)^2$, oscillation will result. As I, D, and S are not controllable by the automatic pilot, it becomes at once evident that for error control to provide an asymptotic return, the aircraft must be something over critically damped in the first place. The higher the natural damping of the ship, the greater the static stability factor that can be supplied by the automatic pilot without causing oscillation. By the same token, the tightness of control obtainable through a straight error system depends on aircraft coefficients. The value of control supplied by the automatic pilot which brings the ship to the point of critical damping is the point of maximum tightness.

Now if the airplane is naturally underdamped and error control is added, the oscillatory motions will be aggravated. Of if the ship is so nearly critically damped that no appreciable amount of control is possible, overshoot or inadequate control will have to be tolerated. These situations can be corrected if extra damping can be provided by the automatic pilot. This may be accomplished by introducing an error rate signal into the amplifier in addition to the error signal. Such a signal may be obtained by a derivative network from the error signal or generated directly from a rate gyroscope. If R is the rate constant and $Rd\Theta/dt$ the rate component of the automatic pilot applied control moment, then

$$I\frac{d^2\Theta}{dt^2} + (D+R)\frac{d\Theta}{dt} + (S+E)\Theta = 0 \qquad (13)$$

This shows that apparent damping can be introduced through the automatic pilot by means of error rate control.

Sometimes this damping is introduced to compensate for a lack of damping produced by aircraft design or high altitude. Sometimes it is introduced in conjunction with large error control moments in cases where tight control is desired. In the latter instance, the rate control serves to absorb the high kinetic energy imparted by the large error control moment.

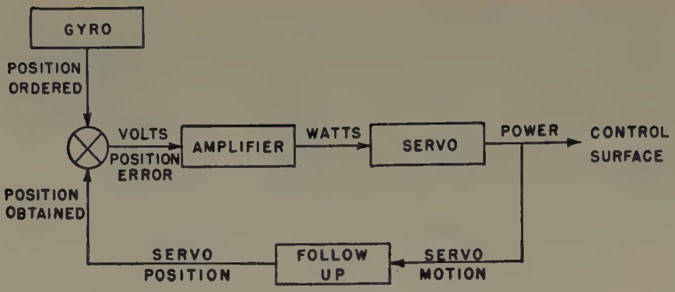


Figure 6. Block diagram of a servomechanism

By a similar process of reasoning the acceleration or second derivative of error displacement can be made to affect the apparent inertia of the ship. If A is the acceleration constant and $Ad^2\Theta/dt^2$ the acceleration component of the automatic pilot applied control moment, then

$$(I+A)\frac{d^2\Theta}{dt^2}+(D+R)\frac{d\Theta}{dt}+(S+E)\Theta=0 \tag{14}$$

This may be somewhat more obscure physically than the effects of rate and displacement but it is none the less true. With error acceleration control through the automatic pilot, an aircraft will accelerate more slowly away from reference under the influence of a given disturbance than the same aircraft without acceleration control, just as if the mass were greater in the first than in the second case. It also will display the undesirable feature of mass in increasing the overshooting tendency. If the sign of the acceleration is reversed, the apparent mass of the ship decreases and greater maneuverability results. A superficial consideration might suggest this as a means to expedite return to reference and reduce overshooting tendencies. Unfortunately, for the same reason it departs more readily from reference. Hence, the desirability of increasing or decreasing apparent mass as such is highly questionable.

However, acceleration control is useful. As noted earlier, control surface deflection means angular acceleration. A lag in the application of control surface means less angular acceleration and all that depends upon it. Therefore, instantaneously, a control surface lag produces results very similar to increased mass. As a considerable amount of electromechanical equipment intervenes between the signal generator and the control surface, a lag between origination of signal and application of control moment is bound to occur. This means that angular acceleration is missing for a measurable period of time. If the response of the ship is slow compared with this lag, it normally can be neglected. However, if the airplane response is fast and the control lag appreciable by comparison, then the deliberate introduction of an error acceleration signal opposing inertia will make up, at least in some degree, for the acceleration loss sustained because of lag. This is the usual reason for introducing acceleration control.

The control surface itself and associated rigging are the chief contributors to lag. The surface can be considered a freely rotating body and a moment equation similar to the one for the ship applies. The torque applied by the cables at the surface hinge corresponds to the control moment. It is opposed as before by inertia, damping, and static stability. The static stability, in this instance, is the positional moment against which the pilot or automatic pilot operates.

Figure 8 shows the complete servomechanism loop with additional notations. The three types of signals are shown although all three might not necessarily be required. By varying the amounts of these signals any type of control may be obtained. In very soft control, stability comes almost entirely from the ship's natural characteristics, the automatic pilot providing only persistent control about reference. In moderate control, displacement alone usually will suffice in pitch and roll with rate added in yaw. In tighter control rate is necessary all around, and in very tight control acceleration must be added. It is possible under very tight control to stabilize to within half a degree in moderately rough conditions. The ship, of course, must be built to take it. It is clear that the tighter the control, the higher the frequency at which the ship is driven, and, from a pendulum analogy, increasing tightness soon can demand prohibitive power from the servomotor. Or, if servomotor power is maintained constant, increasing tightness attenuates the angular departure limits of effective control. Tight control is the hobgoblin of theorists and has justifiable use only in a few specialized craft. Moderate to soft control most commonly is used because it is safer, more comfortable, and easier on the aircraft.

It might be suggested that airplanes be designed highly stable in the first place and thereby eliminate the need for an automatic pilot altogether. This is a specious deduction because stability and maneuverability are incompatible. A highly stable airplane could be very dangerous, especially in rough air. Furthermore, a persistent reference must be provided for long term orientation. As a matter of fact, the exact opposite is preferable. The haphazard motions of an uncontrolled aircraft in turbulent air may be considered to be the aircraft's attempts to realign its own co-ordinates with the shifting co-ordinates of the incident air mass. The ship's natural stability controls to these shifting co-ordinates while the artificial stability

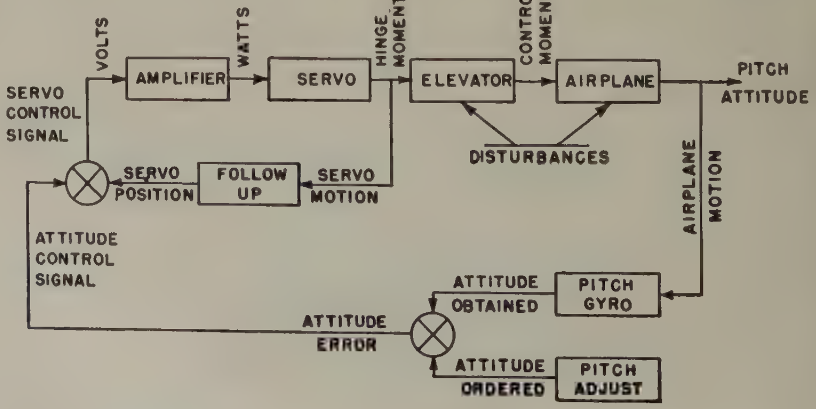


Figure 7. Complete loop of a servomechanism as it pertains to the pitch axis

supplied by the automatic pilot controls to the immobile co-ordinates of the gyroscope. Thus, the smaller the amount of natural damping and the more that is left to the automatic pilot to supply, the smoother the ride.

It is worth noting that the maximum power and speed required of the servomotor for satisfactory control can be calculated. It is redundant, therefore, and inviting trouble to provide excess power and speed. Holding power to a minimum prevents the application of excessive control moments that might damage the structure, and holding speed to a minimum effectively inserts a low pass filter in the loop and excludes the transmission of the higher frequencies, such as those of structural resonance.

The use of displacement, rate, and acceleration might bring up the question of integral control. Integral control could be used to re-establish the flight attitude when an unbalancing moment persists, for instance, a shift in center of gravity because of passenger movements, fuel consumption, and so forth. When such a shift occurs, a new neutral position of the control surface is required to provide a different balancing moment if the established attitude is to be maintained. With rate follow-up the new position is obtained automatically. But with position or force follow-up it is necessary, in effect, to move the follow-up transmitter. This could be accomplished electrically by opposing the follow-up signal with the integral of the error displacement. Integral control as such is not provided but a means to achieve a sort of integral control is usually available to the pilot in the form of trim adjustments. By these adjustments he can introduce a signal to aid the reference and thereby re-establish the attitude. These trimming adjustments also provide a convenient means of making desired changes of attitude in flight without disengaging the automatic pilot.

Most automatic pilots do provide automatic trim tab control. A trim tab is a small adjustable surface hinged at or near the trailing edge of the control surface. The aerodynamic force on the tab produces a moment about the control surface hinge and deflects the control surface to produce a control moment. The tab, in effect, adjusts the aerodynamic null of the surface to permit it to maintain constant control moments to counteract persistent unbalance. This obviates the necessity for the pilot or automatic pilot to maintain a constant load on the control cables. Automatic trim tab control consists of an amplifier and a small motor connected through a gear train and linkages to the trim tab. The motor runs until the aerodynamic null agrees with the electrical null of the net input to the amplifier. Its motion is therefore an integral of a sort with respect to the net signal input. With position or force follow-up, the electrical null does not agree with reference null after a steady unbalancing moment occurs, but automatic trim tab control at least brings aerodynamic and electrical nulls into coincidence. This relieves the servomotor from maintaining a continuous torque and removes the possibility of having the ship jump suddenly to a new attitude upon disconnection of the automatic pilot.

THE MANEUVERING AUTOMATIC PILOT

As automatic pilots became more accurate and reliable, it was natural that more functions be demanded of them. If they could fly a ship straight and level in response to a gyroscope, could they not maneuver the ship in response to the will of the pilot? They could, and they did. So, following the relief automatic pilot, the next stage in the evolution of automatically controlled flight was the maneuvering automatic pilot. It enabled the pilot to maneuver the airplane by the manipulation of simple controls. The idea is old, probably as old as automatic pilots, but it has been only within the last decade that simple, easily operated maneuvering automatic pilots have been reduced to practice.

Maneuvers consist of combinations of turns and climbs or dives. Turns are made by inducing a rate of turn about the vertical axis and adjusting the bank angle about the longitudinal axis to bring the vertical axis into coincidence with the dynamic vertical. The result is a co-ordinated turn during which the airplane does not skid or slip. Climb and dive are functions of pitch attitude and engine thrust. Co-ordinated turns are accomplished by the action of the rudder and ailerons in response to the movement of a single knot or handle available to the pilot. Pitch attitude is changed similarly by elevator in response to the movement of another knob. Thrust has to be controlled manually through the throttles.

The two most common methods for obtaining a rate of turn is to drive the yaw reference around at the desired rate, or to eliminate the yaw displacement signal and bias the yaw rate signal to produce the desired turn. Proper bank is obtained by trimming or biasing the roll reference in the correct proportion with respect to rate of turn. To change pitch attitude a similar trimming signal is introduced to aid or oppose the pitch gyroscope signal. The action of this trimming system is illustrated in Figure 9. It is similar on all three axes.

The design and operation of a maneuvering automatic pilot best can be illustrated by following through the electromechanical schematic of the Eclipse-Pioneer *PB-10* shown in Figure 10. The amplifier unit contains the three voltage and power amplifiers for the servomotors, and houses the pitch and

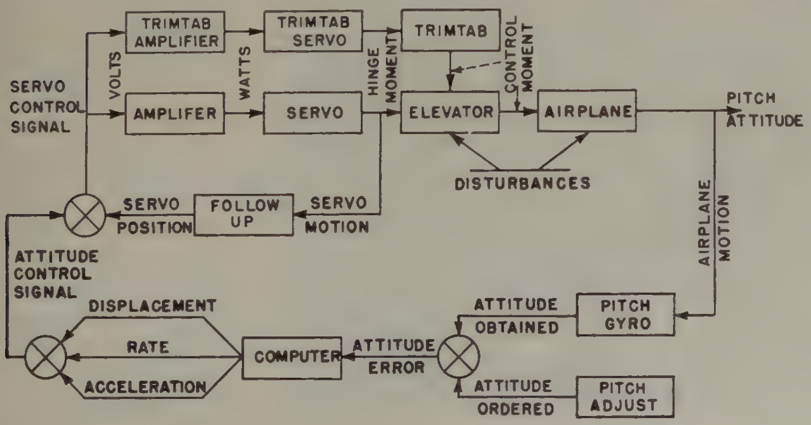


Figure 8. Complete servomechanism loop

bank vertical gyroscopes, the yaw rate gyroscope, an altitude control, and the compass amplifier. The three servomotors are connected to the ship's control surfaces by slave cables to the servomotor drums. The cable drums are disconnected from the servomotor by an electric clutch when the automatic pilot is disengaged. The transmitter of the Gyro Fluxgate Compass is the gyro-stabilized sensing unit of an earth inductor compass. Its signals are amplified to operate the master direction indicator which is mounted in the cockpit and gives visual indication of direction. A course Autosyn in the indicator provides yaw displacement reference for the rudder channel. The controller is mounted in the cockpit and furnishes the pilot with a means for maneuvering the ship. The clutch switch, also in the cockpit, engages and disengages the servomotor and course Autosyn clutches. Because the course Autosyn and the servomotors are self-synchronous, the automatic pilot can be engaged in any attitude and that is the attitude in which the airplane will be held until altered from the controller by the pilot. The action can be analyzed by tracing the signal circuits. These circuits are series voltage and start at ground to pass through the various signal Autosyns to the first grid in the voltage amplifier. Though all the Autosyns are in the circuits all the time, they transmit only when rotated from null.

This automatic pilot, in addition to performing the routine of straight and level flying, provides an easy means for maneuvering, so that the pilot may concentrate on other matters even when turning. Manual operation is by no means the only method of control. Remote control by radio from the ground or mother ship or control from a bombsight are common practices. There is another use, relatively new, which is becoming more important. Some aircraft cannot be flown manually at high speeds. Here the automatic pilot is a must and, because of its quick response and accurate control, permits flight which otherwise would be impossible. Although maneuvering automatic pilots are being improved constantly, they are a successful accomplished fact today.

COMPLETE FLIGHT PATH CONTROL

The third stage of automatic pilot development is that of complete flight path control. We barely have crossed the threshold into this vast and fascinating field. The scope of automatic flight is so immense and the possibilities so manifold that it is impossible to give an adequate picture in a few paragraphs.

Basically, flight path control seeks to solve problems of navigation. The motivating idea is to accomplish complete control from take-off to landing by performing automatically all normal and perfunctory operations. In addition to controlling all airfoil surfaces, including tabs and flaps, the complete automatic pilot must control engine thrust. Landing gear also comes within its domain because flight begins and ends on the ground. The field includes piloted aircraft, pilotless aircraft, and guided missiles. Between these, the details differ but the fundamentals are the same. Flight path control is a problem of controlling to navigational parameters. A flight path can be described completely in terms of ground track, vertical or altitude track, and ground speed. If we establish references defining these three elements and then control the airplane with respect to these references we will accomplish the prescribed flight path. Although many ramifications are possible, the normal present-day references for ground track are manifold radio beams which the airplane can

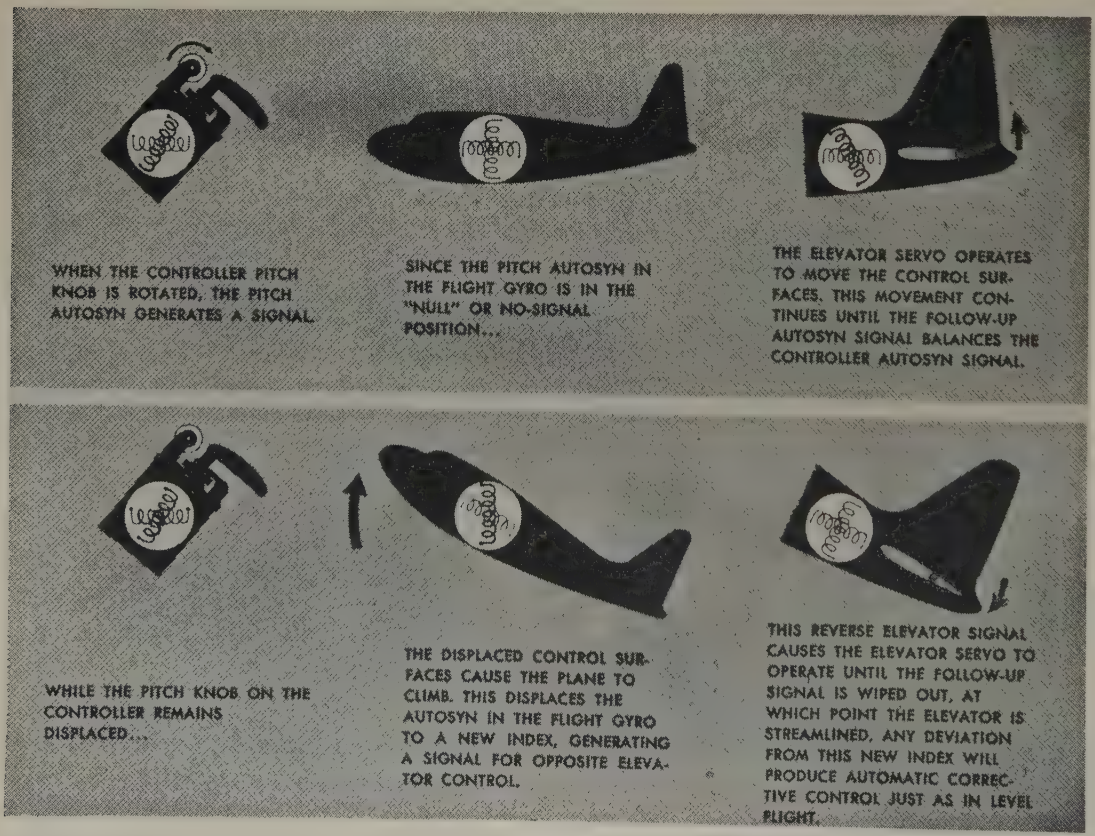

WHEN THE CONTROLLER PITCH KNOB IS ROTATED, THE PITCH AUTOSYN GENERATES A SIGNAL.
SINCE THE PITCH AUTOSYN IN THE FLIGHT GYRO IS IN THE "NULL" OR NO-SIGNAL POSITION...
THE ELEVATOR SERVO OPERATES TO MOVE THE CONTROL SURFACES. THIS MOVEMENT CONTINUES UNTIL THE FOLLOW-UP AUTOSYN SIGNAL BALANCES THE CONTROLLER AUTOSYN SIGNAL.
WHILE THE PITCH KNOB ON THE CONTROLLER REMAINS DISPLACED...
THE DISPLACED CONTROL SURFACES CAUSE THE PLANE TO CLIMB. THIS DISPLACES THE AUTOSYN IN THE FLIGHT GYRO TO A NEW INDEX, GENERATING A SIGNAL FOR OPPOSITE ELEVATOR CONTROL.
THIS REVERSE ELEVATOR SIGNAL CAUSES THE ELEVATOR SERVO TO OPERATE UNTIL THE FOLLOW-UP SIGNAL IS WIPED OUT, AT WHICH POINT THE ELEVATOR IS STREAMLINED. ANY DEVIATION FROM THIS NEW INDEX WILL PRODUCE AUTOMATIC CORRECTIVE CONTROL JUST AS IN LEVEL FLIGHT.

Figure 9. Automatic pilot pitch trimming system

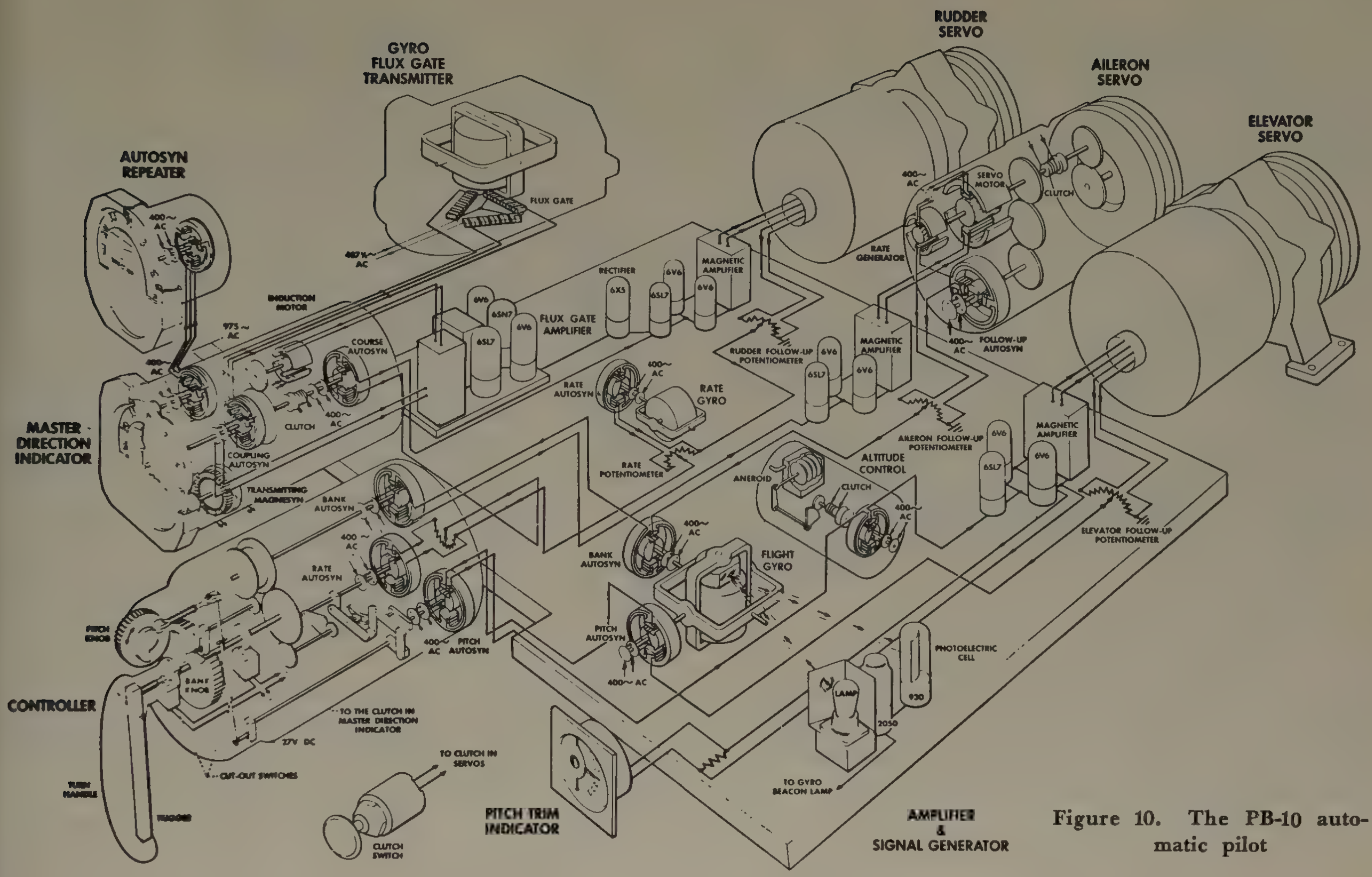


Figure 10. The PB-10 automatic pilot

follow down the center of the take-off runway, cross country, and down the center of the landing runway. The normal altitude references are glide path beams to the runway and barometric and radio altitudes. Ground speed, at present, is effected by monitoring check points along the way and varying air speed to give desired ground speed. We have, therefore, three errors to effect control: lateral displacement from ground track, vertical displacement from altitude track, and longitudinal displacement from ground speed. The problem is one of three dimensional rectangular co-ordinates but its solution is too complex to give more here than just a slight indication of its nature.

Figure 11 displays the situation pictorially. As track is a function of heading, track error applies corrective heading control. Rate of climb or dive and constant altitude (zero rate of climb) is a function of power. Therefore altitude error adjusts the power output of the engines. Air speed is a function of pitch attitude and so speed error modifies pitch attitude. (Within a narrow range elevator may be used to maintain constant altitude.) Figure 12 shows the block diagram of air speed control applied to the elevator channel of the automatic pilot. Practical qualifications increase the difficulty of solution. Physiological and structural limitations require accelerations to be so small as to seem ridiculous compared with usual dynamic problems. The extreme accuracy and stability demanded, especially at the runway, are all out of proportion compared to the size of the airplane. Imagine requiring projectile accuracy at the target to be plus or minus ten per cent of the projectile's own lateral dimension. As a result of the basic nature and the limitations imposed, it is certainly one of the most complex and difficult control problems ever presented. Its complete solution will represent stupendous expenditures of effort, time, and money.

Controlling to navigational parameters is by no means

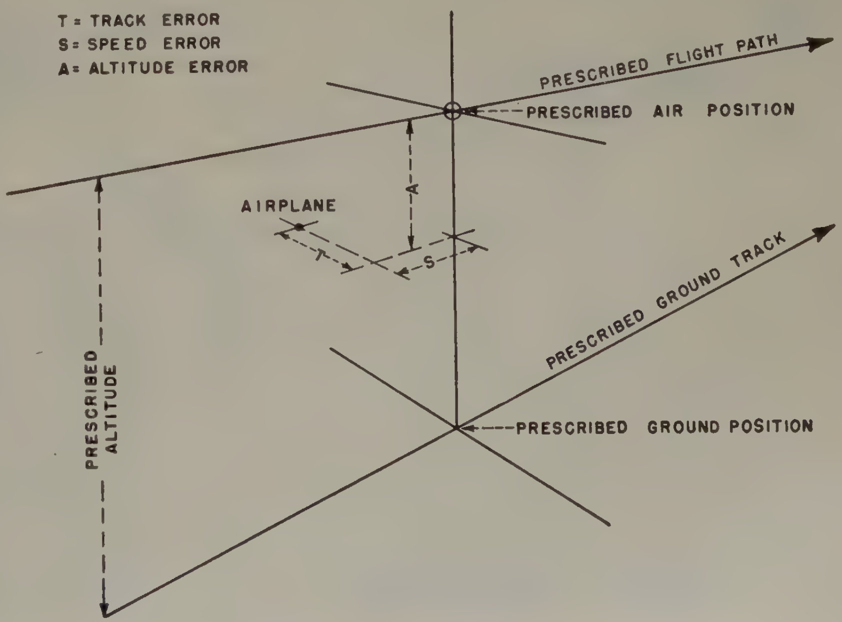


Figure 11. References for complete flight path control

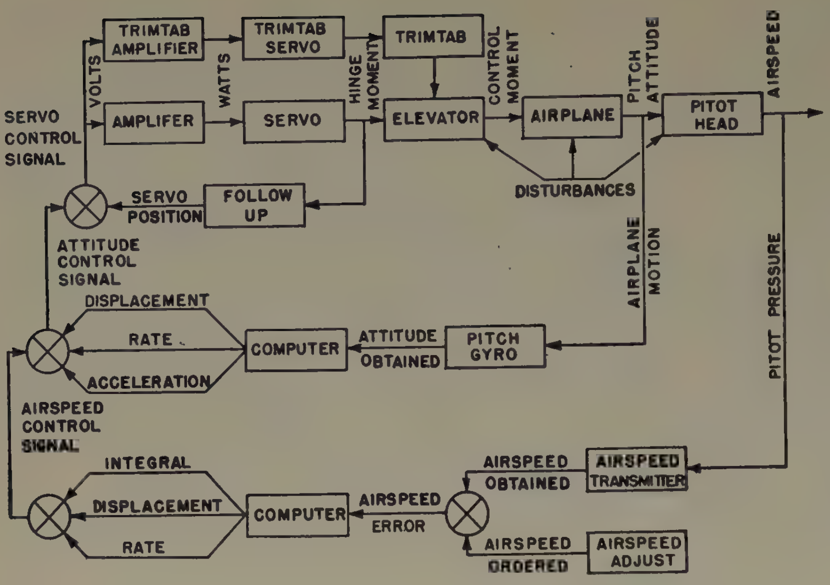


Figure 12. Block diagram of air speed control applied to elevator channel

new. Altitude and air speed control were attempted quite a few years ago through the automatic pilot elevator channel, and various beam flying experiments have been going on for some time. The most elaborate and complete experimentation has been carried out by the United States Army Air Force, but only through the utilization of an enormous amount of equipment.

A very useful and desirable piece of automatic flight equipment has become recently available for commercial use. This equipment forms a coupler between the radio receivers of the instrument landing system and the automatic pilot. It controls the aircraft to the localizer and glide path beams to permit very low approaches in all kinds of weather. The pilot actually lands the ship manually. This same equipment can be used to fly the very-high-frequency and omniranges cross country. Figure 13 shows the approach equipment and the automatic pilot as manufactured by Eclipse-Pioneer.

The justification of automatic flight path control in piloted aircraft lies in the fact that the present methods of control have reached about their limit. The pilot is furnished with all manner of instrumentation and radio facilities to insure safe operation and navigation of the aircraft, but modern transports are so profusely equipped

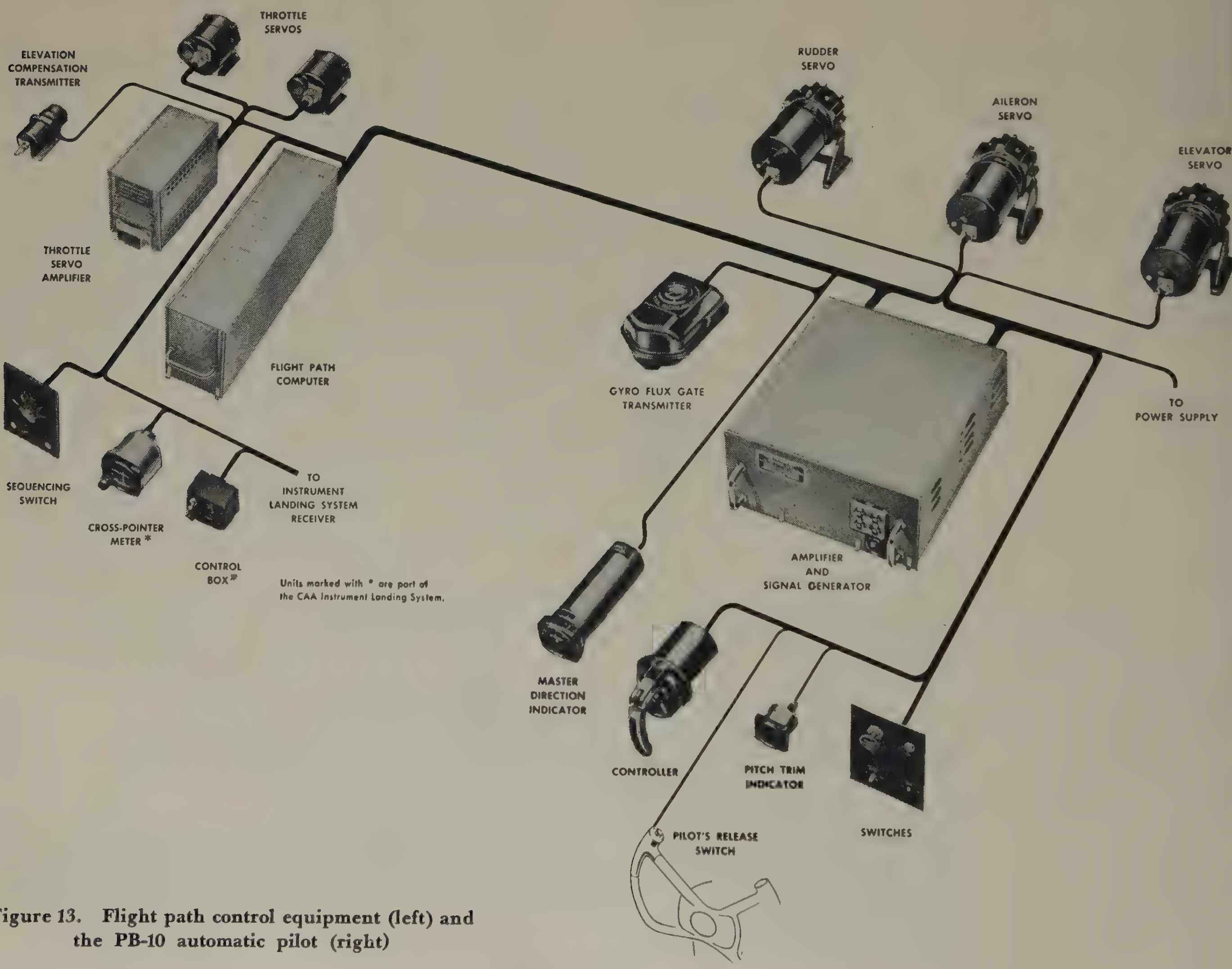


Figure 13. Flight path control equipment (left) and the PB-10 automatic pilot (right)

that the pilot visually is saturated. Almost all information, either internal or external of source, must be received by the pilot, interpreted, and translated manually into action. The multitude of operations is simply too much to do. Automatic flight in its commercial form will not supplant the pilot but will perform the routine of flying and leave him free for other duties. In its complete form it will present to the pilot a means for selecting various references by mere switching and perform the accomplishment of these references automatically. Full realization of economic and strategic potentialities cannot be attained until control is fully automatic.

Another factor looms on the horizon. As air speeds increase, response times to flight path inaccuracies must decrease. Eventually it will become physically impossible to execute a predetermined flight path manually because of the limiting factor of human response. In the old stick and wire days, a pilot could fly "low and slow" leisurely following the iron compass (railroad tracks). If he got lost he could set down in a cow pasture and inquire his whereabouts. Such methods are not possible today. A pilot must stick to the radio ranges of the airways, locate the airport, and perform a precise routine in approach and landing.

At higher speeds the problem becomes intensified and the limits narrower. Again the specter of human response presents itself. Just as the maneuvering automatic pilot was capable of controlling to stability parameters impossible to the human pilot, so the flight path automatic pilot is capable of controlling very high speed flight to navigational parameters otherwise unattainable. For the future advancement of air-borne activity, economic and strategic, the achievement of automatic flight is not a matter of choice, it is absolutely mandatory.

The Electrical 48's

THAT the science of electricity is not new is evidenced by an interesting historical survey of electrical events in 1748 and 1848 which appears in the January 16, 1948, issue of the English magazine, *Electrical Review*.

In 1748 Benjamin Franklin just had begun those electrical researches that made so profound a stir in the scientific world. John Freke published a paper with the imposing title: "An Essay to Show the Cause of Electricity and Why Some Things Are Non-Electricable, in Which Is Also Considered Its Influence in the Blasts on Human Bodies, in the Blights on Trees, in the Damps in Mines, and as It May Affect the Sensitive Plant." Freke was read widely in his day as indicated by a reference to his work in Henry Fielding's novel "Tom Jones" completed that year. When "Black George" re-establishes marital harmony by thrashing his wife, Fielding says:

> The whole family soon was reduced to a state of perfect quiet; for the virtue of this medicine, like that of electricity, is often communicated through one person to many others who are not touched by the instrument. To say the truth, as they both operate by friction, it may be doubted whether there is not something analogous between them, of which Mr. Freke would do well to inquire before he publishes the next edition of his book.

Another 1748 work was by Gowin Knight whose magnetic researches were inspired by a flash of lightning affecting a ship's compass. The title was "An Attempt to Demonstrate That All the Phenomena in Nature Can Be Explained by Two Simple Active Principles, Attraction and Repulsion, Wherein the Attractions of Cohesion, Gravity, and Magnetism Are More Particularly Explained." Also published in that year was "Essays Towards Discovering the Laws of Electricity" by John Ellicott, to which was added part of a letter from the Abbe Nollet to Martin Folkes concerning electricity. On January 21, 1748 Sir William Watson read a paper on electricity before the Royal Society quoting from Franklin's famous letter to Collinson, and elaborating the theory that in an electric machine the glass globes and associated apparatus have not the electric power in themselves but serve only as "the first movers and determiners of that power."

By 1848 Faraday had made most of his discoveries. Kelvin was beginning his thermodynamic researches; James Prescott Joule was investigating the mechanical equivalent of heat; and Hermann von Helmholtz was founding that branch of the general theory of physical energy which embraced electricity and magnetism as well as heat and motion. On the practical side, in that year the electric lamp of Greener and Staite was exhibited in Trafalger Square in London; a new system of electric illumination was used in the Palais Royal theatre in Paris; Henley's magnetoelectric telegraph was patented; and Peltier's induction electrometer was invented. The revolution in 1848 that expelled the Bourbons from France made Dominique Arago, the French astronomer, a member of the provisional government. As professor at the École Polytechnique he had been noted for his researches in light polarization, galvanism, and magnetism. His discovery of the "development of magnetism by rotation" had won for him the Copley Medal of the Royal Society. This medal was presented in 1848 to Sir Charles Wheatstone.

The revolution's ramifications caused the exile from Italy of Giovanni Caselli, noted for his discoveries in the use of electricity as a motive force. During the upheaval in Germany Emil Dubois-Reymond, the physiologist, published a volume in which he determined and analyzed animal electricity; and Heinrich Wilhelm Dove published his "Treatise on Electricity." Other publications included some of the last papers of William Sturgeon whose inventions covered the whole field of electrical science; a textbook on electricity by Alexander Bain; and the electricity handbook of Sir William Snow Harris who applied lightning conductors to ships and public buildings.

Standardization by Electrical Manufacturers

FRANK THORNTON, JR.
FELLOW AIEE

STANDARDS are very important to the whole electrical industry: to the user of electricity in its multitude of applications, to the power company which produces the electricity and delivers it to the user, to the manufacturer of the machinery and equipment, to engineers and architects, and to the general public. From the generators to the utilization apparatus, everything is connected together by a system of wires. Without nationally accepted standards satisfactory performance would be very difficult to achieve.

Standards are adopted in the public interest and are intended to eliminate misunderstandings between the manufacturer and the purchaser and to assist the purchaser in selecting without delay the proper product for his particular need. Existence of a standard does not in any respect preclude any manufacturer from supplying products that do not conform to the standard if the purchaser desires them or is willing to accept them. Standardization must not result in fixation of design and elimination of progress. Standards must be reviewed frequently and changed at any time that progress in the art makes changes necessary or desirable.

The organizations in the United States which are most prominent in standardization in electric power generation, distribution, and utilization are AIEE, the American Standards Association (ASA), the National Electrical Manufacturers Association (NEMA), and the Edison Electric Institute (EEI). Other organizations participate also to an important extent.

AIEE Standards cover such fundamental engineering problems as nomenclature, methods of test, performance, and basis for design as indicated in the following quotation from the foreword of each of its Standards publications:

> In forming Institute Standards the chief purpose has been to define terms and conditions which characterize the rating and behavior of electric machinery and apparatus, with special reference to acceptance tests.

The Standards of AIEE are the foundation on which is built the body of standardization in the electrical industry.

The American Standards Association provides the procedure under which producers, consumers, independent experts, and governmental agencies meet together to formulate standards that can be accepted generally as a basis for commerce. The procedures of ASA required that representatives of all producers and all consumers shall have an opportunity to participate in the formulation of any standard. Its regulations requiring that a proposed standard must be accepted by a practical "consensus" of those concerned with it assure its acceptability as an "American Standard."

The National Electrical Manufacturers Association is a trade association of manufacturers of almost every kind of equipment for the generation, transmission, distribution, and utilization of electric power. It co-operates with other branches of the industry, both directly and through the procedures of ASA and other standardizing organizations, in the development of standards affecting in any way the production of electric products. It has participated in the development of all electrical standards issued by ASA and all such standards have been approved by it. Also it carries on a vast and continuing activity in the development of its own body of standards. Co-ordination of standards applying to the various components of the electric system is a function to which the association contributes greatly.

Problems often arise which involve the application of electric equipment in some particular industry. Joint committees of representatives from different branches of the industry for the study of these problems have been very successful in arriving at satisfactory solutions. Because the products of the manufacturers must be acceptable to the purchasers, must be safe, must be as low in cost as possible to assure expanding usefulness, and must be susceptible to repetitive manufacture, NEMA takes an active interest in all phases of the development and application of standards which affect the products of its members.

The following is a partial list of sources of published standards:

AIEE—American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N. Y.

ASA—American Standards Association, 70 East 45th Street, New York 17, N. Y.

ASME—The American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N. Y.

ASTM—American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

ATA—American Transit Engineering Association, 292 Madison Avenue, New York, N. Y.

EEI—Edison Electric Institute, 420 Lexington Avenue, New York 17, N. Y.

IPCEA—Insulated Power Cable Engineers Association, 420 Lexington Avenue, New York, N. Y.

IRE—Institute of Radio Engineers, One East 79th Street, New York 21, N. Y.

NBS—National Bureau of Standards, Washington 25, D. C.

NEMA—National Electrical Manufacturers Association, 155 East 44th Street, New York 17, N. Y.

NFPA—National Fire Protection Association, 60 Batterymarch Street, Boston 10, Mass.

RMA—Radio Manufacturers Association, 1317 F Street, N. W., Washington, D. C.

UL—Underwriters' Laboratories, Inc., 207 East Ohio Street, Chicago 11, Ill.

Digest of paper **48-135**, "Standardization by Electrical Manufacturers," recommended by the AIEE Standards committee and approved by the AIEE technical program committee for presentation at the AIEE summer general meeting, Mexico, Federal District, Mexico, June 21–25, 1948. Not scheduled for publication in AIEE *TRANSACTIONS*.

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Lightning-Resistant Transmission Line Performance

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A LITTLE more than ten years ago a study was made of the lightning performance of all overhead wood pole transmission lines of the Northern Indiana Public Service Company. This study started with the year 1932. The record showed that the company was experiencing 40.1 lightning outages per 100 circuit miles per year, other type outages averaged 31.7

Transmission lines with wide conductor separation, utilizing wood insulation to full advantage but with shielding wires omitted, resulted in a lightning outage record not quite as good as that of the older lines of miscellaneous design.

However, a 69-kv line with grounded shielding wire, steel braced arms and steel bayonets, and grounds, some good and some poor, had an excellent record.

This study induced the adoption of shielding and grounding on all new wood pole transmission lines and on improvements to existing lines, with full use made of the insulating value of wood. Structural design also was simplified.

Ten years have passed since the principles of shielding and grounding wood pole transmission lines were adopted. These ten years, together with the previous period of six years, afford an interesting and valuable operating record on four general types of lines. A summary of this record is given in Table I, which is shown graphically in Figure 1. Figure 2 shows the outage record of all 33-kv and 69-kv lines by years.

The following conclusions may be drawn:

1. Full advantage of the impulse insulation strength can be obtained by inexpensive methods.

2. Because of the shape of the lightning severity curve, flashovers from lightning decrease more rapidly than the ratio of increased structure impulse insulation strength.

3. Ground resistance should be determined by the protection desired and the minimum impulse insulation of any of the conductors by any of its possible flashover paths.

4. It is desirable that the minimum flashover path be directly from conductor to down lead wire through air and not over wood in order that splintering of wood will be avoided.

5. Small high-strength shielding wires result in inexpensive construction. The few cases of trouble to date do not justify larger conductors and more expensive construction. This item should be reviewed from time to time to be certain that the present opinion is not based on insufficient data.

6. It is to be expected that ultimately this transmission system will be practically immune to lightning. Outage expectancy will be of the order of one outage per 100 miles per year, and few of these will cause damage.

7. No application of pure engineering theory has produced results more gratifying than to see the reduction of lightning outages of the entire system almost directly in proportion to prediction.

Table I. Operating Summary of Various Types of Construction

Line Type	Year Miles	Miles Last Year	Years Service Inclusive	Outages Per 100 Circuit Miles Per Year: Lightning	Other	Total
33-kv,* all types	4719.1	674.3	1932 to 1938	40.1	31.7	71.8
Wood insulation	683.1	71.2	1932 to 1947	48.9	29.6	78.5
Semimodern	721.6	45.1	1932 to 1947	6.5	21.1	27.6
Modern design	968.6	112.7	1938 to 1947	1.0	5.1	6.1

* Nonlightning resistant except that about 5.6 per cent were shielded.

Digest of paper 48-126, "Ten Years' Performance of Lightning-Resistant Wood Pole Transmission Lines," recommended by the AIEE transmission and distribution committee, and approved by the AIEE technical program committee for presentation at the AIEE summer general meeting, Mexico, Federal District, Mexico, June 21–25, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

R. M. Schahfer is mechanical and electrical engineer, and **W. H. Knutz** is special engineer, Northern Indiana Public Service Company, Hammond, Ind.

Figure 1. Lightning outages by types of construction

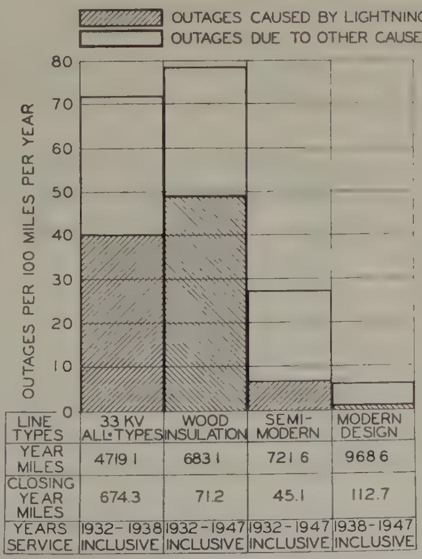
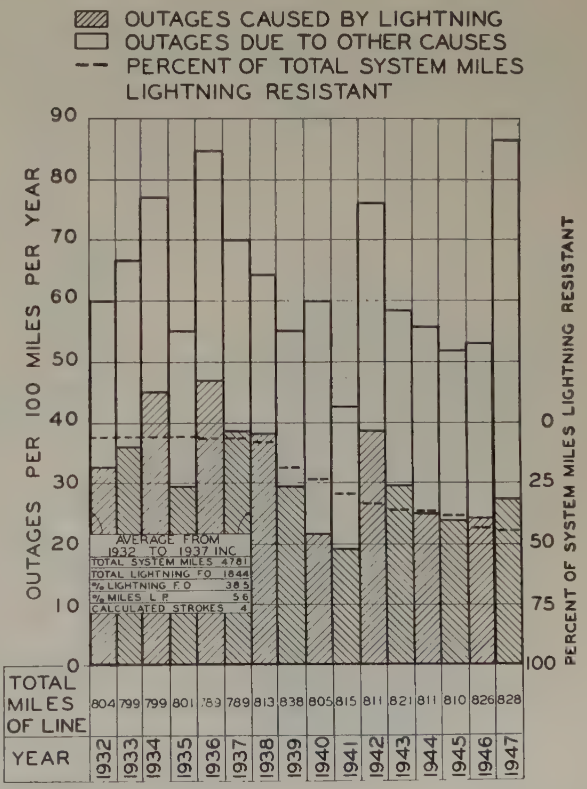


Figure 2 (right). The 33-kv and 69-kv system

Lightning outages by years



A New Isolated-Phase Metal-Enclosed Bus

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R. B. SHORES
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THE DESIGN of bus runs for high capacity generating stations always has received considerable attention in order to insure freedom from faults of any type. A metal-enclosed nonventilated isolated-phase bus has been developed which combines a high degree of reliability with immediate accessibility for inspection or maintenance. By questioning operating, construction, and consulting engineers the following specifications were established to guide the development of the new design:

1. Ultimate design is to permit shipment of complete factory-assembled sections to reduce field installation time to a minimum.

2. Designs must permit maximum accessibility for inspection or maintenance so that any insulator, or bus section, can be inspected, or even removed and replaced, in the shortest possible time. As some busses will be installed in hazardous locations, such as on scaffolding or suspended from ceilings, unbolting or handling of heavy, loose covers is to be avoided by hinging the covers.

3. The number of porcelain insulators is to be kept to a minimum consistent with strength requirements in order to reduce the number of creepage surfaces as each creepage surface constitutes a potential flashover point.

4. Angular and longitudinal flexibility should be designed into the bus and enclosure junctions so that no high accuracy alignment is necessary in the field which would increase the cost of installation.

5. Longitudinal flexibility is to be designed into the bus junctions to provide for thermal expansion and contraction of long runs without introducing strains in either bus supports or porcelain insulators.

6. The metal enclosures are to be dusttight to prevent reduction of the flashover strength over insulator surfaces.

7. The metal enclosures should be weathertight so that they can be installed either indoors or outdoors without special construction.

8. Temperature rise limitations, 60-cycle high-potential withstand tests, and basic impulse withstand tests are to be in accordance with AIEE Standards for station-type switchgear.

9. A generous margin of mechanical strength is to be designed into the bus supports to withstand the maximum magnetic forces associated with the rated momentary short-circuit currents.

10. Metal enclosures are to be constructed of nonmagnetic material to eliminate magnetic heating and thereby permit minimum cross section conductors.

11. Seal-off bushings are to be provided at appropriate locations to act as arc and gas barriers to prevent the possibility of a phase-to-ground arc within an enclosure running along the entire bus length.

Details of the completed bus design are shown in Figure 1. The enclosure consists essentially of a single aluminum sheet shaped to form three of the sides, while the fourth side consists of a gasketed hinged cover. The channel bus is supported on standard porcelain insulators which normally are carried in stock in all power stations at the present time. Silver-surfaced semiflexible copper connections are used to connect the end of each channel section to the next section, thereby providing angular flexibility, as well as providing for thermal expansion and contraction of the bus. The porcelain insulators supporting the bus are mounted, in turn, on removable heavy steel supporting brackets which are bolted solidly through the housing to the main H beam cross member. Each end of the housing fits into the gasketed groove of an aluminum end plate. A circular flange with in insulating gasket around its circumference projects from these end plates. Simple split aluminum banding rings then are used to span the distance between the end plates of adjacent sections. A heavy continuous longitudinal ground bus extends the full length of the bus run and is connected to each section. Figure 2 shows an individual phase shipping section of the new bus. The new design has been given complete high-potential, impulse-withstand, heat-run, and weather tests. Sample sections also have been subjected to momentary current tests considerably in excess of their ratings with no evidence of any damage.

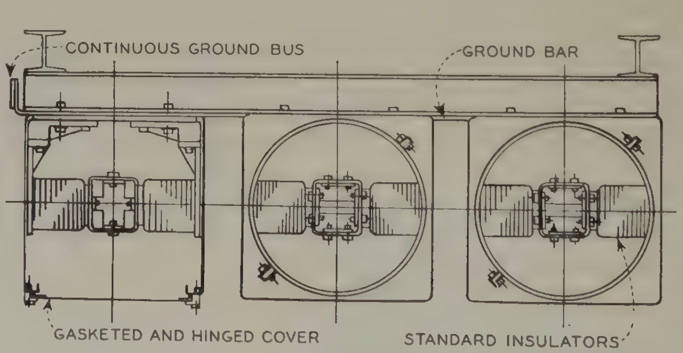

Figure 1 (above). A 3-phase assembly of the new bus consisting of three individual phase housings suspended from two H-beam cross members which constitutes a 3-phase shipping section

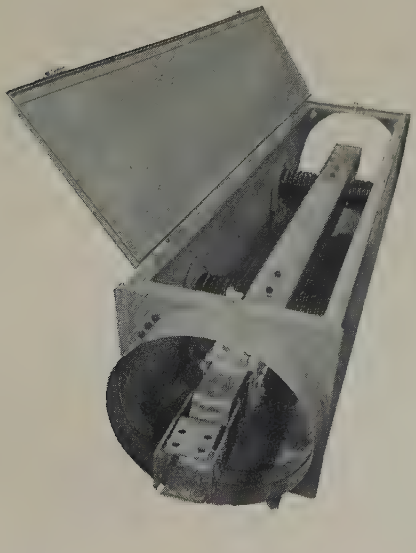

Figure 2 (left). A single-phase section of the new bus with the cover open showing ready accessibility for maintenance

This section has a continuous current rating of 4,000 amperes and a momentary short-circuit current rating of 130,000 amperes

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Digest of paper 48-169, "A New Isolated-Phase Metal-Enclosed Bus Designed for High Capacity Generating Stations," recommended by the AIEE switchgear committee and approved by the AIEE technical program committee for presentation at the North Eastern District meeting, New Haven, Conn., April 28–30, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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An Equivalent Circuit for the Repulsion Motor

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Equivalent circuit analysis has been developed for most types of electric machinery and has proved to be a valuable aid in design, understanding, and calculations. The equivalent circuit for the repulsion motor should find its place among older analyses as an optional alternate approach to performance calculations and motor design.

THE USE of the equivalent circuit for the polyphase induction motor as an aid to the theory of operation and performance calculations is well known. Equivalent circuits also have been developed for other motors, such as the single-phase induction motor, the capacitor motor, the osnos motor, the schrage motor, and recently, problems in the realms of mechanics, thermodynamics, hydraulics, and electrodynamics have been solved by means of equivalent electric circuits.

An equivalent circuit for the repulsion motor does not appear to have been developed, and it is hoped that its presentation might be of use in the performance calculations and design of the motor.

PERFORMANCE EQUATIONS OF THE REPULSION MOTOR

The circuit diagram of the repulsion motor is shown in Figure 1. The supply voltage is connected directly across the field and the armature brushes are short-circuited. The field and compensating functions are performed by a single stator winding, and the brush axis is displaced at an angle α with respect to this winding as shown in Figure 1.

In establishing the equations of performance, the following assumptions are made:

1. Windage, friction, iron losses, and the effects of saturation are neglected.
2. The windings are distributed such that the mutual inductance between them varies as the cosine of the electrical angle between their axes.

The flux produced by the stator winding may be resolved into two components, one acting along the brush axis and the other at 90 electrical degrees to it. It is useful to regard these components of flux as produced by two separate stator coils connected in series. Thus, in Figure 2 the "transformer" coil T produces an alternating flux along the brush axis, and induces a current in the armature by transformer action. The mutual inductance between this winding and the armature is $M \cos \alpha$* henries. The "field" coil F produces an alternating flux along an axis at 90 electrical degrees to the brush axis. The armature flux linkages produced by this coil are $M \sin \alpha \boldsymbol{I}_s \times 10^8$ and rotation of the armature at an angular velocity of v electrical radians per second generates a voltage in the armature circuit of $vM \sin \alpha \boldsymbol{I}_s$ volts. The voltage equations of the stator and rotor respectively are

$$V=(R_s+L_s p)\boldsymbol{I}_s - M \cos\alpha\, p\boldsymbol{I}_a \tag{1}$$

$$0=(R_a+L_a p)\boldsymbol{I}_a-(M \cos\alpha p - vM \sin\alpha)\boldsymbol{I}_s \tag{2}$$

where $(R_s+L_s p)\boldsymbol{I}_s$ and $(R_a+L_a p)\boldsymbol{I}_a$ are the instantaneous voltage drops because of self inductance of the stator and armature windings respectively, and $M \cos \alpha p\boldsymbol{I}_s$ and $M \cos \alpha p\boldsymbol{I}_a$ are the instantaneous induced voltages in the stator and armature windings respectively.

If the steady state solution only is required, the operator p may be replaced by $j\omega$, and equations 1 and 2 become

$$V=(R_s+jX_s)\boldsymbol{I}_s - jX_m \cos\alpha \boldsymbol{I}_a \tag{3}$$

$$0=(R_a+jX_a)\boldsymbol{I}_a-(jX_m \cos\alpha - sX_m \sin\alpha)\boldsymbol{I}_s \tag{4}$$

The solution of equations 3 and 4 for $\boldsymbol{I}_s$ and $\boldsymbol{I}_a$ gives

$$\boldsymbol{I}_s=V/Z \tag{5}$$

where

$$Z=R_s+jX_s+\frac{X_m^2 \cos^2\alpha}{R_a+jX_a}+\frac{1}{2}\left(\frac{sX_m^2 \sin 2\alpha}{X_a-jR_a}\right) \tag{6}$$

is the equivalent impedance referred to the stator.

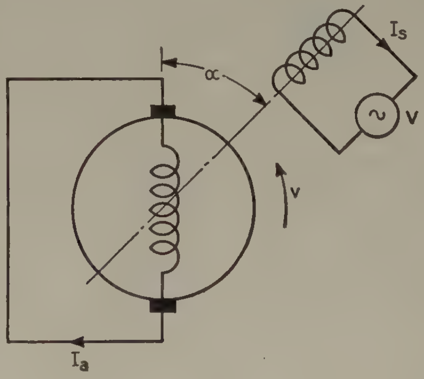

Figure 1. Repulsion motor with single field coil

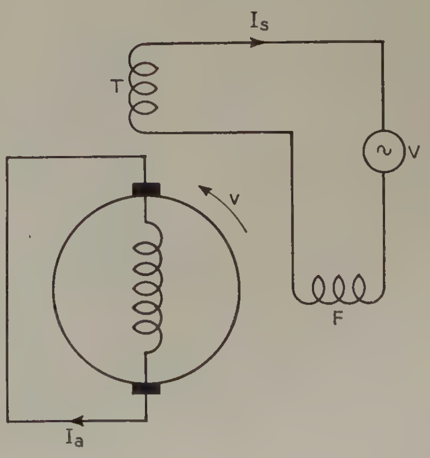

Figure 2. Repulsion motor with double field coil

F—Field coil
T—Transformer coil

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* For definition of symbols, see the appendix.

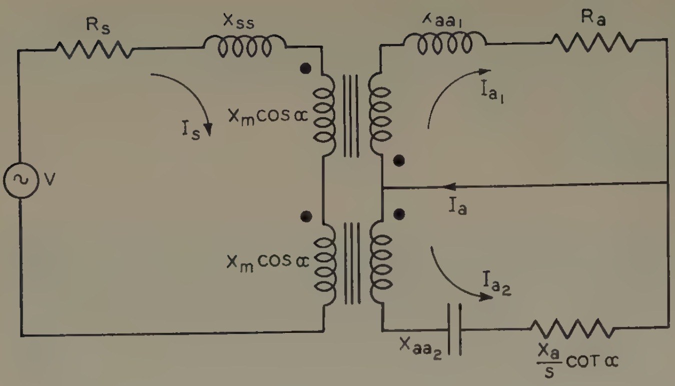


Figure 3. Equivalent circuit for repulsion motor

$$X_{ss}=X_s-2X_m\cos\alpha$$
$$X_{aa_1}=X_a-X_m\cos\alpha$$
$$X_{aa_2}=X_m\cos\alpha+\frac{R_a}{s}\cot\alpha$$

$$\boldsymbol{I}_a=\left[\frac{jX_m\cos\alpha}{R_a+jX_a}+\frac{jsX_m\sin\alpha}{X_a-jR_a}\right]\boldsymbol{I}_s \tag{7}$$

The armature current consist of two components $\boldsymbol{I}_{a_1}$ and $\boldsymbol{I}_{a_2}$, such that

$$\boldsymbol{I}_a=\boldsymbol{I}_{a_1}+\boldsymbol{I}_{a_2} \tag{7a}$$

where

$$\boldsymbol{I}_{a_1}=\frac{jX_m\cos\alpha}{R_a+jX_a}\boldsymbol{I}_s \tag{8}$$

$$\boldsymbol{I}_{a_2}=\frac{jsX_m\sin\alpha}{X_a-jR_a}\boldsymbol{I}_s \tag{9}$$

The component $\boldsymbol{I}_{a_1}$ is the current induced in the armature by the transformer coil *T*, whereas the component $\boldsymbol{I}_{a_2}$ is the current due to the rotation of the armature in the flux from the field coil *F*. It is evident from equations 8 and 9 that current $\boldsymbol{I}_{a_2}$ leads current $\boldsymbol{I}_{a_1}$ by 90 degrees in phase.

EQUIVALENT CIRCUIT

In forming the equivalent circuit for the repulsion motor, it is convenient to write equations 6 and 7 in the form

$$\boldsymbol{Z}=R_s+jX_s+X_m^2\cos^2\alpha\left[\frac{1}{R_a+jX_a}+\frac{1}{\frac{1}{s}\cot\alpha(X_a-jR_a)}\right] \tag{6a}$$

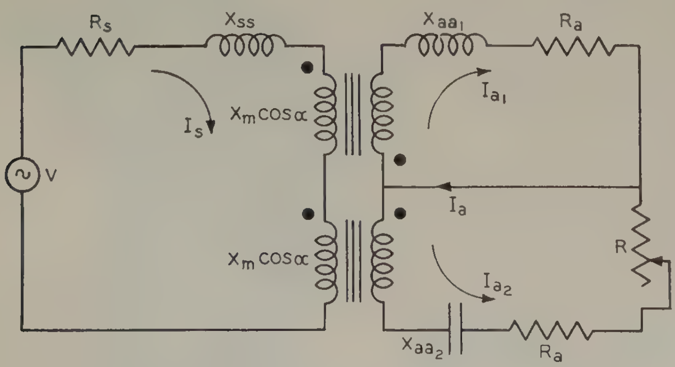


Figure 4. Equivalent circuit showing load resistance

Load Resistance $R=\frac{X_a}{s}\cot\alpha-R_a$

$$\boldsymbol{I}_a=\boldsymbol{I}_{a_1}+\boldsymbol{I}_{a_2}=\left[\frac{jX_m\cos\alpha}{R_a+jX_a}+\frac{jX_m\cos\alpha}{\frac{1}{s}\cot\alpha(X_a-jR_a)}\right]\boldsymbol{I}_s \tag{7b}$$

Then, equations 5, 6*a*, and 7*b* may be represented by the equivalent circuit shown in Figure 3.

TORQUE

The torque may be calculated from the equivalent circuit by a consideration of copper loss in the secondary circuits as follows

$$\text{Rotor input}=R_a I_{a_1}^2+\frac{X_a}{s}\cot\alpha\, I_{a_2}^2$$

$$\begin{aligned}\text{Rotor loss}&=R_a I_a^2\\&=R_a(|\boldsymbol{I}_{a_1}+\boldsymbol{I}_{a_2}|)^2\\&=R_a(I_{a_1}^2+I_{a_2}^2)\end{aligned}$$

as $\boldsymbol{I}_{a_1}$ and $\boldsymbol{I}_{a_2}$ are in quadrature.

Rotor output = Rotor input − Rotor loss

thus

$$P=\left[\frac{X_a}{s}\cot\alpha-R_a\right]I_{a_2}^2 \tag{10}$$

From equation 9

$$I_{a_2}^2=\frac{s^2X_m^2\sin^2\alpha}{R_a^2+X_a^2}I_s^2$$

Substituting for $I_{a_2}^2$ in equation 10 gives

$$P=\frac{sX_m^2\sin\alpha}{R_a^2+X_a^2}(X_a\cos\alpha-sR_a\sin\alpha)I_s^2 \tag{11}$$

The steady state torque in synchronous watts is thus

$T=P/s.$

Equation 10 indicates that the output of the motor is equivalent to a variable resistance

$$R=\frac{X_a}{s}\cot\alpha-R_a$$

connected in the armature mesh carrying the current $\boldsymbol{I}_{a_2}$. The load resistance R is shown in the equivalent circuit of Figure 4.

CIRCLE DIAGRAM

The circle diagram for the stator current may be derived from the equivalent impedance of the motor

$$\boldsymbol{Z}=R_s+jX_s+X_m^2\cos^2\alpha\frac{(R_a-jX_a)}{R_a^2+X_a^2}+{}^1/_2\left[sX_m^2\sin 2\alpha\frac{(X_a+jR_a)}{R_a^2+X_a^2}\right] \tag{6b}$$

Table I. Typical Constants for a 5-Horsepower 400-Volt 50-Cycle 4-Pole Variable Speed Repulsion Motor

R_s	0.797 ohm
X_s	40.4 ohms
X_m	5.15 ohms
R_a	0.0472 ohm
X_a	0.745 ohm
Z_a	0.746 ohm
α	40 degrees (assumed)
$X_m\cos\alpha$	3.95 ohms
X_{ss}	$X_s-2X_m\cos\alpha$ $40.4-7.90=32.5$ ohms
X_{aa_1}	$X_a-X_m\cos\alpha$ $0.745-3.95=-3.20$ ohms (capacitance)
X_{aa_2}	$X_m\cos\alpha+\frac{r_a}{s}\cot\alpha$ $3.95+0.0563/s$

which is of the form

$$Z = Z' + sZ'' \qquad \textbf{(6c)}$$

where Z' and Z'' are complex constants depending upon the design of the machine and s is the "speed ratio." Typical constants for a 5-horsepower 400-volt 50-cycle 4-pole variable speed repulsion motor are given in Table I.

The equivalent load resistance is

$$R = \frac{X_a}{s}\cot\alpha - R_a$$
$$= (0.888/s) - 0.0472$$

If

$$s = 0.8$$
$$R = 1.063 \text{ ohms}$$
$$\theta = \arctan\frac{R_a}{X_a}$$
$$= 3 \text{ degrees } 38 \text{ minutes}$$

Substitution of these values in equation 6*b* gives the constants

$$Z' = 2.12 + j\,19.51$$
$$Z'' = 17.49 + j\,1.11$$

for use in equation 6*c*. The locus of Z, determined by equation 6*c* is a straight line shown in Figure 5.

The locus of the reciprocal of Z is a circle of diameter OA, and is determined as follows:

Draw the locus of the conjugate of Z and join any point C on this locus to the origin O. The point D, such that $OD = 1/OC$, lies on the locus of $1/Z$. The diameter of the circle is determined as $OA = 1/OB$, where OB is perpendicular to the locus of the conjugate of Z.

The angle θ is equal to arctan R_a/X_a. The stator current is determined by the equation

$$I_s = V(1/Z)$$

so that for a constant stator applied voltage V, the locus of the stator current is the same as the locus of $1/Z$ excepting for a change in scale.

It is convenient, however, to rotate the diagram through 90 degrees as shown in Figure 6.

The loci of the induced armature current I_{a_1} and the generated armature current I_{a_2} are determined from equations 8 and 9, observing the fact that the two currents are in quadrature. Both loci are circles (Figure 6).

As the total armature current I_a is the vector sum of I_{a_1} and I_{a_2}, its locus is also a circle.

With reference to Figure 5, the minimum value of impedance Z is OB which is equal to 19.34 ohms, thus the diameter of the locus circle for I_s is

$$I_{s\,\max} = \frac{400}{19.34} = 20.68 \text{ amperes}$$

Equation 8 gives the diameter of the locus circle for I_{a_1} as

$$I_{a_1\max} = \frac{X_m \cos\alpha}{Z_a} I_{s\max} = \frac{5.15 \times 0.766}{0.746} \times 20.68$$
$$= 109.5 \text{ amperes.}$$

From equations 5, 6*c*, and 9,

$$I_{a_2} = \frac{jX_m \sin\alpha}{X_a - jR_a} \times \frac{V}{Z'/s + Z''}$$

The minimum value of $|Z'/s + Z''|$ is 17.27 ohms, therefore

$$I_{a_2\max} = \frac{5.15 \times 0.643}{0.746} \times \frac{400}{17.27} = 102.9 \text{ amperes,}$$

which is the diameter of the locus circle for I_{a_2}. The vectors shown in Figure 6 represent stator and armature

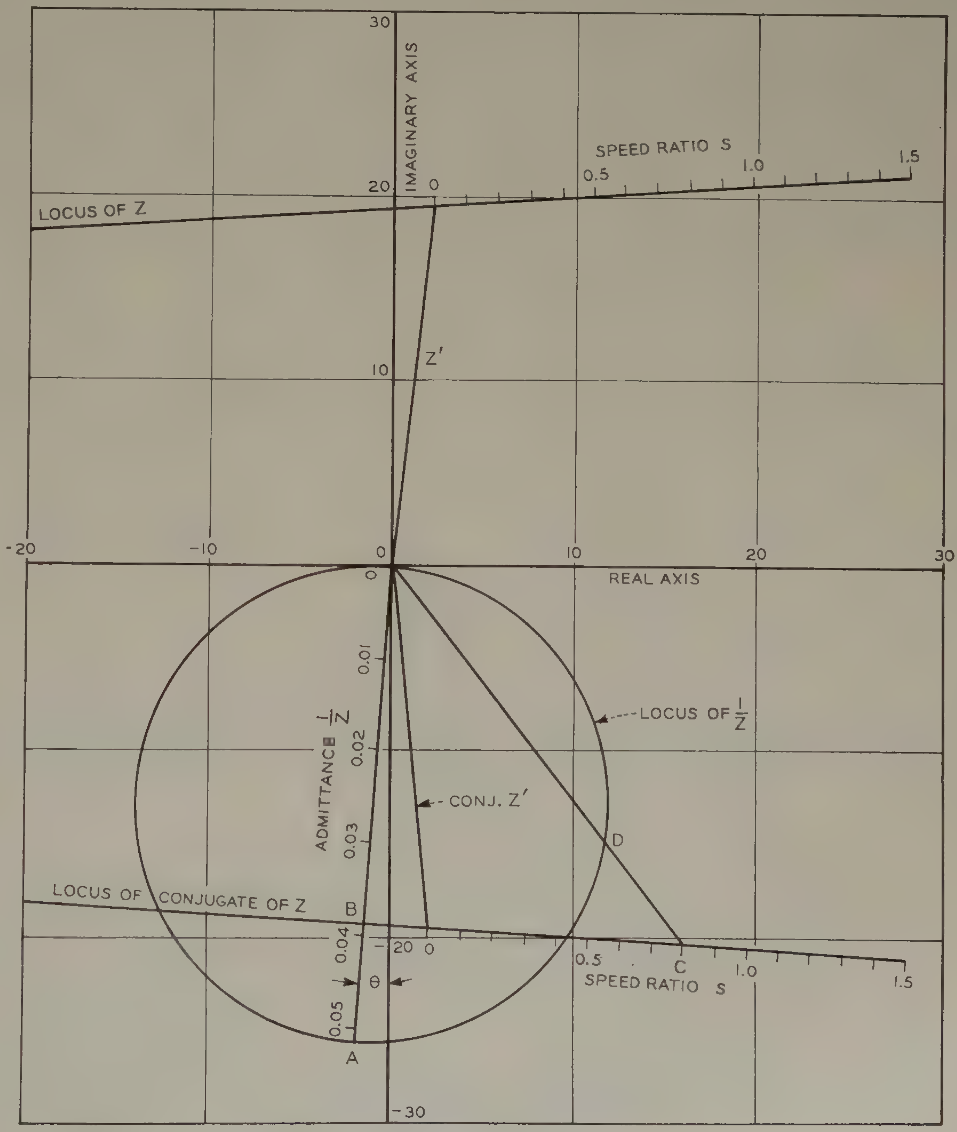


Figure 5. Admittance circle diagram

currents at a speed of 1,200 rpm ($s=0.8$). Scaling these vectors from the diagram,

$I_s=15.4$, $I_{a_1}=81.5$, $I_{a_2}=54.7$, $I_a=98.3$ amperes.

The power output at speed ratio $s=0.8$ is

$P=I_{a_2}^2R=(54.7)^2\times1.063=3{,}180$ watts.

This figure may be checked from equation 11, thus

$$P=\frac{sX_m^2\sin\alpha}{Z_a^2}(X_a\cos\alpha-sR_a\sin\alpha)I_s^2$$

$$=\frac{0.8\times(5.15)^2\times0.643}{(0746)^2}[(0.745\times0.766)-(0.8\times0.472\times 0.643)](15.4)^2$$

$$=3{,}180 \text{ watts.}$$

$$T=\frac{3{,}180}{0.8}=3{,}975 \text{ synchronous watts.}$$

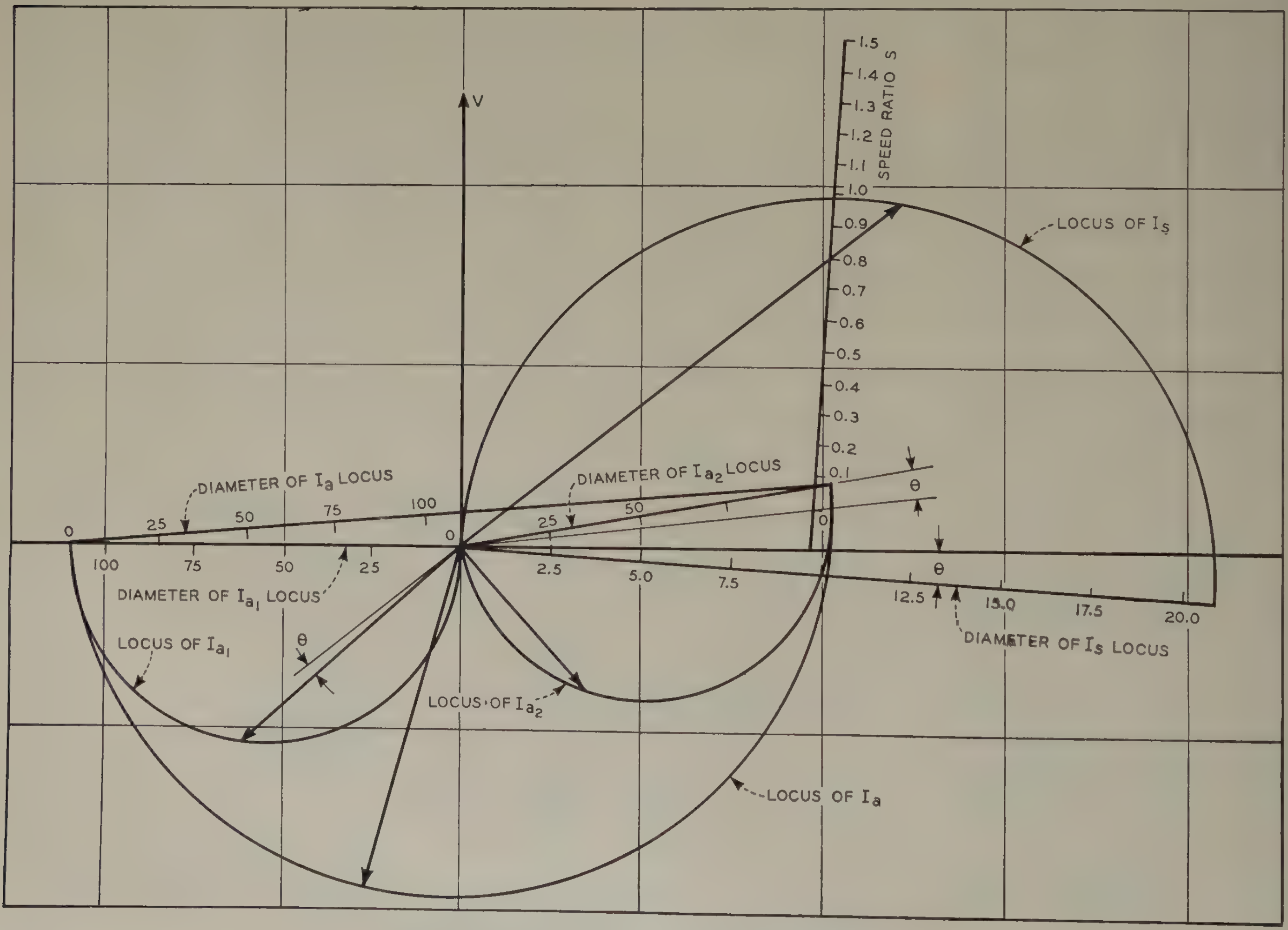
These figures do not include the effects of windage, friction, iron losses, or saturation. However, it is hoped that the equivalent circuit may aid the designer in both transient and steady state analysis of performance of the repulsion motor.

APPENDIX

NOTATION

f=frequency of supply
I_a=armature current
I_{a_1}, I_{a_2}=component of armature current
I_s=stator current
$j=\sqrt{-1}$
L_a=armature self inductance
L_s=stator self inductance
M=mutual inductance between stator and armature windings when the brush axis is in line with the axis of the stator winding
P=rotor output in watts
p=operator $\dfrac{d}{dt}$
R=equivalent load resistance
R_a=armature resistance
R_s=stator resistance
$s=v/\omega$, the speed ratio, which is defined as the ratio of armature speed to synchronous speed
T=torque in synchronous watts
V=stator applied voltage
v=angular velocity of armature in electrical radians per second
$X_a=\omega L_a$, the armature reactance
$X_s=\omega L_s$, the stator reactance
$X_{aa_1}=X_a-X_m\cos\alpha$
$X_{aa_2}=X_m\cos\alpha+\dfrac{R_a}{s}\cot\alpha$
$X_{ss}=X_s-2X_m\cos\alpha$
$X_m=\omega M$
Z=equivalent impedance referred to the stator
$Z_a=R_a+jX_a$, the armature impedance
α=angle between the brush axis and the axis of the stator winding in electrical degrees
$\theta=\arctan\dfrac{R_a}{X_a}$
$\omega=2\pi f$
$|\ |$=modulus or absolute value.

Figure 6. Current circle diagram



Standardization in the United States

HAROLD S. OSBORNE
FELLOW AIEE

THE TERM "standardization" is applied to very diverse fields of activity. This article deals principally with the procedures and activities of the American Standards Association with particular reference to engineering standards of interest to the AIEE. The Institute long has been a leader in this field and was one of a small group of organizations which formed the American Engineering Standards Committee (predecessor of the American Standards Association) in 1918.

In the United States standards, to receive national acceptance, must be designed to serve the interests of the nation as a whole. To be effective they must represent a general consensus of view of those most concerned. The great bulk of national standards, some of which later may be incorporated in government regulations, is developed by the voluntary and co-operative action of the various groups interested.

This approach to standardization has been adopted as the basic principle of operation of the American Standards Association. Through this association more than 2,000 organizations, companies, and individuals co-operate in the development of standards which will be certified as "American Standards" by the association when it has determined that the standard represents a consensus of the interested groups representing producers, consumers, distributors, and other groups, including general interests and government departments.

Within the broad principle of establishing a consensus, the procedures of the American Standards Association provide for a wide variety of methods for the formulation of American Standards. The procedure which is used most widely is the formation of what is called a sectional committee on which is adequately represented all interested groups. The sectional committee usually is sponsored by one (or sometimes by more than one) of the standards-making organizations. The sponsor, the personnel of the committee, the scope of the work to be done by the committee, and the resulting standard are all subject to the approval of the association.

The association operates largely through correlating committees. Standards in the electrical field are supervised by one of these—the Electrical Standards Committee, on which all important groups interested in electrical standards are represented.

In standardizing work, government departments and bureaus participate on the same basis as any other organized technical group or industrial group. Participation in the development of each standard is open to all who have an important interest and particularly those who can contribute information or work are urged to take an active part. At the present time 50 government bureaus are officially represented on committees responsible for 350 standards.

The American Standards Association also represents the United States in international standards bodies. The association was active in the recent formation of the International Standards Organization, of which Mexico also is a member. In the electrical field, the International Electrotechnical Commission for many years has been the authoritative body for international standards. The United States National Committee of the IEC closely is affiliated with the Electrical Standards Committee of the association.

The close integration of domestic and international standardization work has many advantages.

All of this work represents a growing appreciation in the United States as in many other countries of the importance of standards both in improving the economic condition of the country and also in helping to stimulate international trade and improving economic conditions generally throughout the world. Important ways in which standards are helpful include the following:

1. They help to create understanding and avoid disputes. For example, a purchaser can use standards as a basis of stating exactly what he is ordering and determining whether or not he receives exactly what is ordered.

2. They improve working conditions, as emphasized by the numerous safety standards.

3. They assist in the economy of production, as in standard dimensions, standard methods, and standard performance characteristics.

4. They increase convenience of use (as illustrated by interchangeable parts and standards of quality).

5. They reduce trade barriers—within a country and to the extent that they are used by many countries internationally.

6. They are important for defense. This applies not only nationally but internationally to standards used in common by groups of countries who may have occasion, as in the two recent World Wars, to join together to defend themselves against an aggressor.

The association has given special emphasis to developing the closest possible ties in standards work between the United States and the other republics in the Western Hemisphere. To this end, the association has had for a number of years a Latin-American department.

The importance of standardization widely is recognized in both North and South America. Seven American countries have national standardizing bodies: Argentina, Brazil, Canada, Chile, Mexico, United States, and Uruguay. In Mexico standardization has expanded to a broad field of activity. It is to be hoped that close co-operation in standards work in the United States and Mexico will be stimulated still further, thus adding one more tie to those which closely bind together these two friendly neighbors.

Digest of paper **48-136**, "Standardization in the United States," recommended by the AIEE Standards committee and approved by the AIEE technical program committee for presentation at the AIEE summer general meeting, Mexico, Federal District, Mexico, June 21–25, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Effect of Angle Regulator on Power System Stability

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RECENTLY there has been considerable discussion of the benefits with respect to electric power system stability to be obtained by the use of a properly designed angle regulator. An angle regulator applied to a synchronous machine is defined here as a regulator that varies the machine excitation voltage in response to changes in the angle between the rotor interpole axis and the effective system voltage so as to tend to restore the initially set angle. The purpose of this article is to present the results of an analytical exploration of the possibilities of the angle regulator as regards stability. In particular, since voltage regulators already are used extensively, and since their use as aids in power-system stability already has been studied, it has seemed appropriate to compare the action of an angle regulator with that of a voltage regulator.

PRINCIPAL CONCLUSION

The principal conclusion of the present analysis is that the dynamic actions of the angle and voltage regulators near the system stability limit are essentially equivalent, so that their effects on stability can be made practically indistinguishable by proper regulator design. The need for an angle regulator therefore cannot be demonstrated purely on the basis of steady state dynamic stability requirements.

DISCUSSION

In the normal operation of a synchronous generator over its load range it is customary, and indeed it seems highly desirable and almost necessary, to maintain voltage, rather than load angle, constant. Thus if an angle regulator were used it would have to be biased by a voltage regulator at least in the steady state. If it appears worth while to have temporarily a somewhat higher excitation than would result from the normal action of a voltage regulator, it seems at least as simple to accomplish this by modifying temporarily the action of the voltage regulator as by introducing the concept of holding angle. Figures 1 and 2 show some of the results of calculations of the stability limits as affected by an angle regulator and a voltage regulator, respectively. The system considered consists of a synchronous machine of unit synchronous reactance connected to an infinite bus through a tie line of unit reactance, with the machine terminal voltage and power factor maintained at unity in the steady state.

The actual magnitude of the power gain depends in any particular instance on the system conditions, in particular on the relative importance of the machine reactance and the tie-line reactance. In the interpretation of Figures 1 and 2 it is convenient to note that the maximum power limit for curve *A* of both graphs is simply that which would be calculated by using machine transient reactance instead of synchronous reactance. In long-distance power transmission the machine reactance may be relatively smaller so the percentage gains in power limit would be correspondingly smaller, but still would be appreciable and worthy of consideration.

The concept of using transient reactance provides a quick means for estimating the gain which may be obtained by use of a proper regulator, as both calculations and tests have shown that the effects may be approximated by using a reduced machine reactance which may approach the transient value.

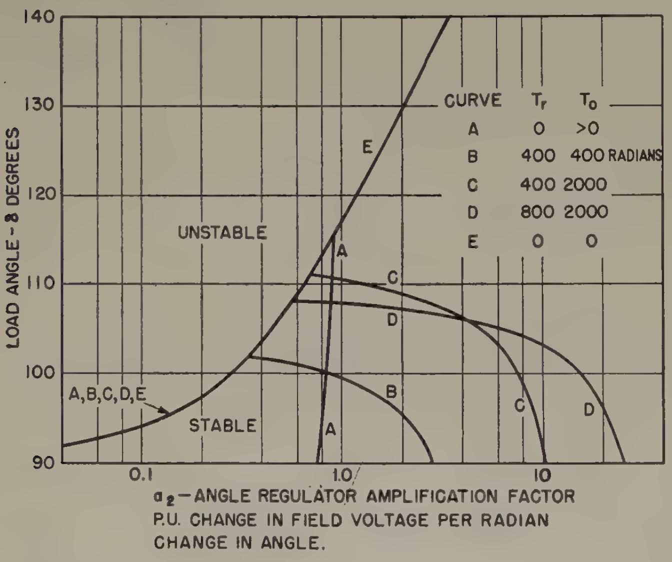

Figure 1. Effect of angle regulator on steady-state stability limit—synchronous machine and tie line

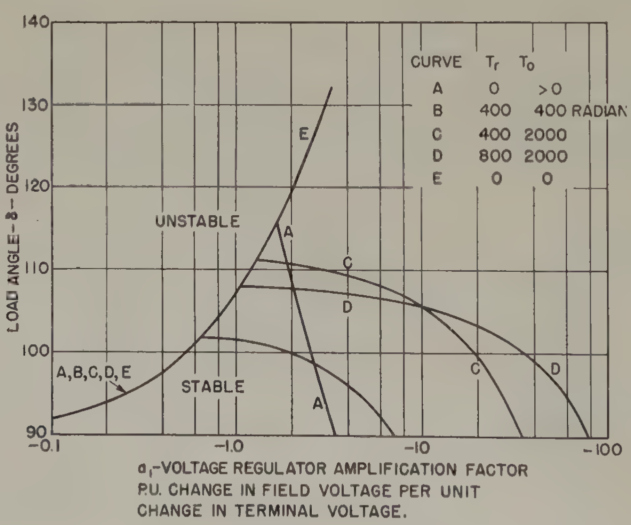

Figure 2. Effect of voltage regulator on steady-state stability limit—synchronous machine and tie line

Digest of paper **48-165**, "Steady State Stability of Synchronous Machines as Affected by Angle Regulator Characteristics," recommended by the AIEE rotating machinery committee and approved by the AIEE technical program committee for presentation at the AIEE North Eastern District meeting, New Haven, Conn., April 28–30, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Magnetostriction Generators

J. A. OSBORN

As the latest of a series of articles reviewing the various known and tried methods of producing electric power, this article presents a survey of fundamental magnetostriction phenomena and their application to the conversion of mechanical to electric energy, or conversely.

THE SUBJECT of this article has to do with the use of magnetostriction effects for the conversion of mechanical to electric energy, or the converse. Thus the word "generator" is used here in the same sense as when applied to rotating machinery that converts mechanical into electric energy. The magnetostriction effects we shall be concerned with involve a change in the dimensions of a magnetic specimen when subjected to a magnetic field, or a change in magnetic properties of that specimen when it is strained mechanically. Up to the present, these effects have not been used specifically for the generation of electric power. Therefore, to gain insight into these effects, so as to see how they might be used, the first section of this article will be devoted to a qualitative discussion of some of the fundamental mechanisms involved in magnetic and magnetostriction phenomena. In the second section, the performance of a representative magnetostriction transducer or "generator" will be analyzed by means of an electromechanical equivalent circuit. This method provides means of visualizing the interaction of electric and mechanical parts in magnetostrictive devices, and predicting results of changing electrical, magnetic, and mechanical parameters of such a device. Of necessity this article cannot be an exhaustive treatment of the subject. Further, it is not possible at this time to refer to some of the important wartime contributions to this subject of such groups as the Bell Telephone Laboratories, the Harvard Underwater Sound Laboratory, and the Columbia University Division of War Research. It is hoped that the list of references will be of help to those wishing to study the subject further.

Domain Interpretation of Magnetic and Magnetostriction Processes

PHYSICAL PROPERTIES OF DOMAINS

The primary source of the magnetic moment in ferromagnetic material is the spin of electrons in certain unfilled shells of the atoms of these materials. At room temperature, conditions for aligning these spins in the same direction are favorable in the common ferromagnetic elements iron, nickel, and cobalt. Groups of these aligned spins are called Weiss domains. Thus the ferromagnetic material is filled completely throughout by spontaneously magnetized regions. However, all of the domains in a material are not aligned in the same direction but may lie in a variety of directions determined by factors to be examined later in this article. The size of these domains varies. Bozorth and Dillinger[1] determined their volume to be about 10^{-9} cubic centimeter, although under special conditions they can be made much larger. Thus if they were assumed to be cubic in shape, they would have a side length of 10^{-3} centimeter. Such a domain is estimated to contain 10^{14} to 10^{15} atoms.

Perhaps the most striking evidence of the existence of domains is shown in Bitter patterns.* It is postulated that the magnetization (magnetic moment per unit volume) of these domains remains constant in magnitude and changes only by rotation of its direction. The other change that can occur in a domain is a volume change. Between adjacent domains oriented in different directions there is a transition region, or domain wall, made up of atoms having magnetic moments that gradually go from the orientation in one domain to that of the adjacent domain. It is possible for this wall to move under certain conditions so that the size of one domain is increased at the expense of its neighbor.

PREFERRED DIRECTIONS IN MAGNETIC MATERIALS

What determines the direction of the magnetization of the various domains? To begin with, we know that the domain magnetization has preferred directions. If the magnetization rotated easily into any direction we should expect that in a polycrystalline material it would be possible to saturate it at extremely small fields. Further, we should not have such things as permanent magnets which need strong disturbing forces to change their magnetization.

As discussed by Becker,[2,3] the preferred direction of domain magnetization J_s is that which reduces the energy ψ to a minimum. This energy consists of three parts: the energy due to magnetic field F_H, crystal or anisotropy energy F_c, and stress energy F_σ. Thus

$$\psi = F_H + F_c + F_\sigma \tag{1}$$

MAGNETIC FIELD ENERGY

The field energy is simply the work per cubic centimeter required to rotate the magnetization J_s out of the direc-

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The author acknowledges the help of P. N. Arnold, head of the transducers research section, sound division, Naval Research Laboratory, in pointing out that the equivalent circuit of a transducer drawing acoustic power from a medium must include the internal acoustic impedance of that medium; also, the instructive discussions on electromechanical analogies held with Doctor H. M. Trent, head of the applied mathematics section, mechanics division.

* F. Bitter applied a suspension of iron oxide ($\gamma = Fe_2O_3$) having particles about 10^{-4} centimeter in diameter, to a polished magnetized surface and observed under the microscope that the powder formed parallel lines regularly spaced about 0.1 millimeter apart. The configuration of these patterns, due to the particles clumping at the magnetic poles formed by the domain boundaries at the specimen surface, gives valuable clues as to the domains' behavior.

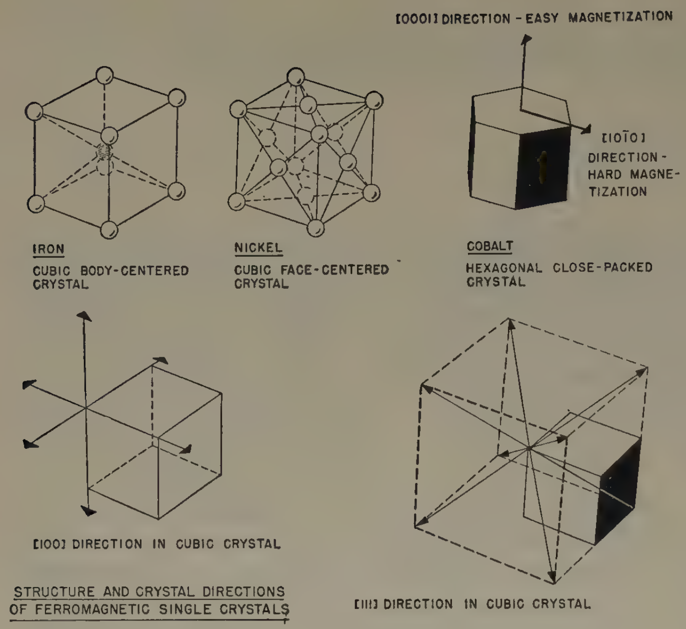

[0001] DIRECTION - EASY MAGNETIZATION
[10̄10] DIRECTION - HARD MAGNETIZATION
IRON
CUBIC BODY-CENTERED CRYSTAL
NICKEL
CUBIC FACE-CENTERED CRYSTAL
COBALT
HEXAGONAL CLOSE-PACKED CRYSTAL
[100] DIRECTION IN CUBIC CRYSTAL
STRUCTURE AND CRYSTAL DIRECTIONS OF FERROMAGNETIC SINGLE CRYSTALS
[111] DIRECTION IN CUBIC CRYSTAL

Figure 1. Structure and crystal directions of ferromagnetic single crystals

tion of the applied field H by an angle φ and may be expressed by

$$F_H=-HJ_s\cos\varphi \quad (2)$$

There is only one preferred direction associated with this field, namely, that in the direction of the applied field.

CRYSTAL ENERGY EFFECTS

The effect of crystal energy in determining preferred directions is shown by the difference in magnetization curves taken in different crystallographic directions in a single crystal.

Directions of Easy and Hard Magnetization. Before introducing such curves, however, let us look at a schematic picture of the crystal structure of iron, nickel, and cobalt at room temperature given in Figure 1. The structure of cobalt is not shown in detail because of its complication. It will be seen that there are six possible (100) directions along the cube edges and eight possible (111) directions along the cube diagonals. There are two possible (0001) directions in cobalt, along the hexagonal axis. The (110) directions not shown in Figure 1 are along a cube face diagonal.

The significance of these directions is shown in Figure 2 by the magnetization curves[4–6] taken along these directions in single crystals. It will be seen that the easy directions of magnetization for iron are the (100) directions, for nickel the (111) directions, and for cobalt the (0001) directions. Along the hard directions considerable work must be done to align the magnetization along the direction of the applied field. This work is indicated by the area between the curves and the ordinate axis. From the nearly vertical rise of these curves in the easy direction it is postulated that the domains lie along these crystal directions in the demagnetized state, held there by crystal forces. They may be rotated out of these directions of easy magnetization by application of a sufficiently large magnetic field in another direction or by stress.

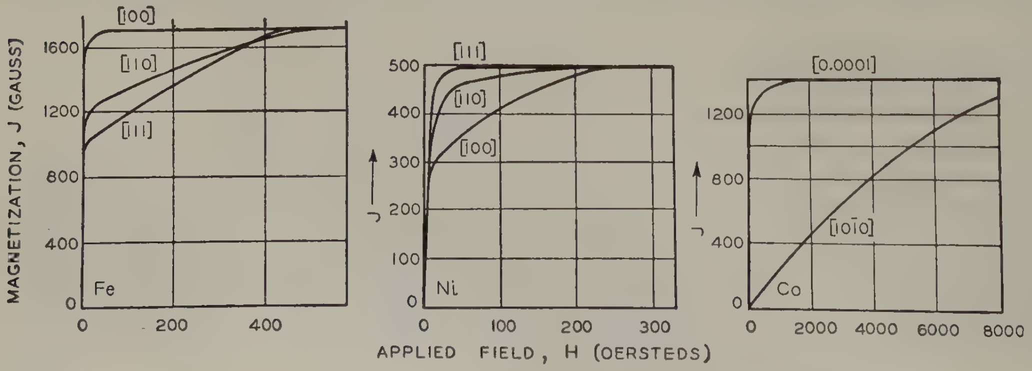
Description of Magnetization Curve by Domain Changes. In a polycrystalline material the crystals are distributed randomly in all directions, so that while the anisotropy effects are still present during magnetization we see an average or smeared out result of these processes. Figure 3 shows a schematic representation of the domain magnetization changes taking place in one of the crystals of a strain-free polycrystalline sample during magnetization. The arrows indicate roughly the portions of the magnetization curve in which these changes are taking place.

Part *1* of the curve shows the demagnetized specimen with the domains lying along various easy directions of magnetization, so that the total magnetization of the specimen is zero. In part *2* a reversible phenomenon is taking place: the walls between differently oriented domains are moving so as to increase the volume of those domains whose magnetization vector is most nearly in the direction of the applied field. The magnetization vector of the individual domains does not change its direction during this process. In part *3*, an irreversible phenomenon is taking place: the domains unfavorably oriented with respect to the applied field suddenly are jumping to directions of easy magnetization oriented most favorably with respect to the applied field. In part *4* a reversible phenomenon takes place: the magnetic field energy now has become strong enough to be the dominant factor in determining the preferred direction and so the magnetization rotates away from the directions of easy magnetization into the field direction. If the field is removed, the magnetization rotates back to the nearest direction of easy magnetization leaving the specimen magnetized at its residual induction.

Crystal Energy Formula and Anisotropy Constants. The dependence of crystal energy in a cubic crystal on the orientation of the domains with respect to the cube edges is indicated by the following approximate formula. Crystal energy F_c is the work per cubic centimeter required to rotate the magnetization out of a (100) a direction into direction having cosines α_1, α_2, and α_3.

$$f_c=k(\alpha_1^2\alpha_2^2+\alpha_2^2\alpha_3^2+\alpha_3^2\alpha_1^2) \quad (3)$$

Figure 2. Magnetization curves of single crystals of iron, nickel, and cobalt along various crystal directions



where

k = anisotropy constant (ergs per cubic centimeter)
α's = direction cosines of domain magnetization with cube edges taken as co-ordinate axes

Figure 4 taken from the work of Bozorth and Williams[7] gives values of the anisotropy constant for a series of iron-nickel alloys. The fact that the anisotropy goes through zero is a factor contributing to the high permeabilities of alloys in this range of composition for it indicates that, other forces being negligible, it takes little energy to align the domains in the direction of the applied field.

STRESS ENERGY EFFECTS

General Remarks. The effect of stress in determining the preferred directions in a magnetic material is shown in Figures 5 and 6. Figure 5 is a hysteresis loop for an annealed polycrystalline nickel rod with a constant tension applied along the field direction.[8] It readily is seen that as the tension increases, it requires more and more work to magnetize the sample.

For nickel the two directions along the axis of tension are not preferred. Figure 6[9] shows what happens when the directions along the line of tension are preferred. As with the other illustration, field and tension are applied along the same line. It is seen that increased tension quickly dominates over crystal forces and makes the directions along the line of tension preferred. A contributing factor to the ease with which the stress energy dominates the crystal energy is the low anisotropy displayed by nickel iron alloys of this composition (Figure 4). Examination of the hysteresis curves of Figure 6 at the higher tensions show that more and more energy is required to rotate the magnetization out of one direction along the axis of tension into the opposite direction. The changes when they take place are by sudden jumps as though the sample were one big domain changing its direction from one preferred direction to the other. Although the analogy is incomplete, this process is somewhat similar to that which takes place in the rising part of the magnetization curve of an unstrained material wherein the domains are jumping from one preferred direction to another with increasing field—only in this instance the preferred directions are determined by crystal rather than by stress effects.

Magnetostriction. The reason for the opposite effects shown by nickel and 78.5 permalloy lies in the different magnetostriction properties of the two materials. The permalloy sample has positive magnetostriction, the nickel specimen negative magnetostriction. A material exhibits positive magnetostriction if it elongates in the direction of an applied field, negative magnetostriction if it shortens in this direction. This change in dimensions is associated with the magnetization vector of the individual domains in the material so that when they are aligned in a given direction, as at saturation, the dimension of the material along the field direction is different than in the demagnetized state when the domains are oriented randomly in all directions.

This relative change in length of a specimen in going from a demagnetized to a saturated state, the saturation magnetostriction, is shown in Figure 7 for a range of iron-nickel alloys.[10] Again note that the magnetostriction is low in the range of 80 per cent nickel. This low magnetostriction is a reason why permalloys in this region show very high initial permeability.

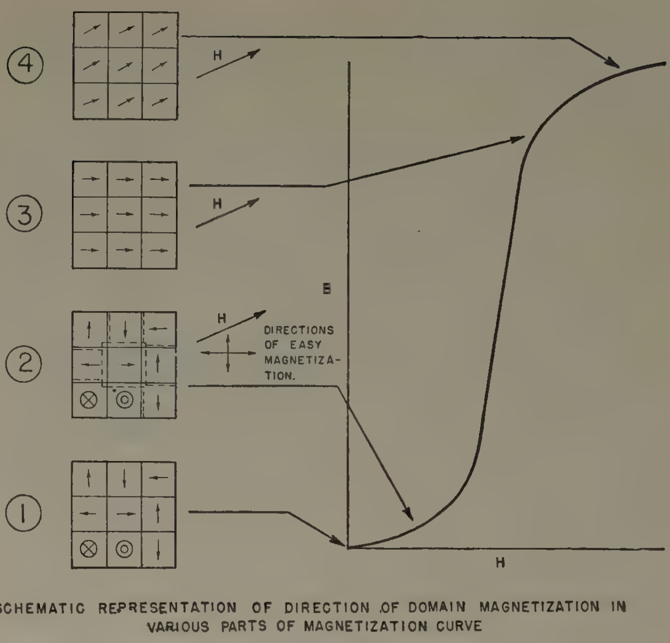

4
H
3
H
B
2
H
DIRECTIONS OF EASY MAGNETIZATION.
1
H
SCHEMATIC REPRESENTATION OF DIRECTION OF DOMAIN MAGNETIZATION IN VARIOUS PARTS OF MAGNETIZATION CURVE

Figure 3. Schematic representation of direction of domain magnetization in various parts of magnetization curve

Domain Interpretation of Magnetization Changes by Stress. Figure 8 gives a schematic domain picture of materials of low anisotropy under tension. The top rectangle shows the domains randomly oriented along various directions of easy magnetization, so that the total magnetization of the material is zero. If tension now is applied to a specimen having positive or negative magnetostriction, as shown by the next row of rectangles, the domains rotate towards the nearest preferred direction determined by the stress. There are two such preferred directions so that, on the average, half of the domains rotate in one direction and half in the opposite direction. The result is that the total magnetization is still zero and there has been no change in the total magnetization of the specimen. The lower set of three rectangles illustrates the effect of giving a resultant magnetization to the specimens before applying tension. If stress now is applied, the resultant magnetization is different

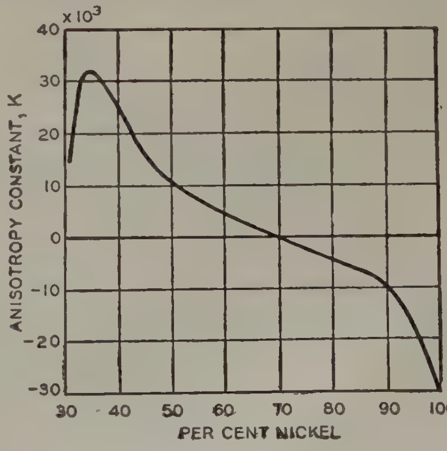


Figure 4. Dependence of crystal anisotropy of iron-nickel alloys on composition

for specimens having positive and negative magnetostriction, but there is a change in magnetization that can be detected by suitable means. This change of magnetization with stress is the effect used in a magnetostriction transducer for converting mechanical into electric energy. From the description just given, it may be understood why it is necessary to polarize magnetically the magnetostrictive cores of such devices if strains in the core are to produce flux changes.

As may be surmised, the magnetostriction of a material has an effect on its Young's modulus. Under stress the domains always tend to rotate so as to increase the strain caused by the stress. Therefore, if a tension is applied to a material having positive magnetostriction, the domains will align themselves along the axis of tension and add the magnetostrictive strain to the pure elastic strain with the result that the effective Young's modulus is lower than that measured when the domains already are lined up as in a strong magnetic field. In the equivalent circuit of a magnetostriction transducer given later it has been necessary to include this effect.

Thermodynamic Equation Relating Reciprocal Effects of Magnetic Field and Stress. There is a close relation between the effect of stress on the magnetization of a specimen in a constant applied field and the effect of a field on the magnetostrictive strain on a specimen under constant stress. This relation is specified in the following equation, where the numerical sign of σ is plus for tension and minus for pressure.

$$\left(\frac{\delta J}{\delta \sigma}\right)_H = \left(\frac{\delta \epsilon}{\delta H}\right)_\sigma \tag{4}$$

J = magnetic moment per unit volume
σ = stress
H = magnetic field
ϵ = magnetostriction—change in length per unit length
(Assumptions: all changes isothermal and reversible)

This equation, which appears to have validity over a wide range of magnetic states,[11] may be derived from purely thermodynamic considerations.[12] It states that if the length of a specimen increases with application of a field (positive magnetostriction), its magnetization also will increase with applied tension ($+\sigma$) or decrease with applied pressure ($-\sigma$).

Stress Energy Equation. A formula for the contribution of stress energy to the energy ψ is given in the following. Stress energy F_σ is the work per cubic centimeter required to rotate the magnetization away from axis of stress by an angle ϕ.

$$F_\sigma = \frac{3}{2}\left(\frac{\Delta l}{l}\right)_s \sigma \sin^2 \phi \tag{5}$$

(isotropic magnetostriction assumed)

Comparison of Crystal and Stress Energy

	Nickel	Iron
(ergs per cubic centimeter)	-5×10^4	4×10^5
$\left(\frac{\Delta l}{l}\right)_s$	-3×10^{-5}	-9×10^{-6}
σ required to make $F_\sigma \simeq F_c$	10^9 dynes per square centimeter, 14,500 lbs. per square in.	3×10^{10} dynes per square centimeter, 440,000 lbs. per square in.
Remarks	Above σ just exceeds elastic limit	Above σ exceeds tensile strength

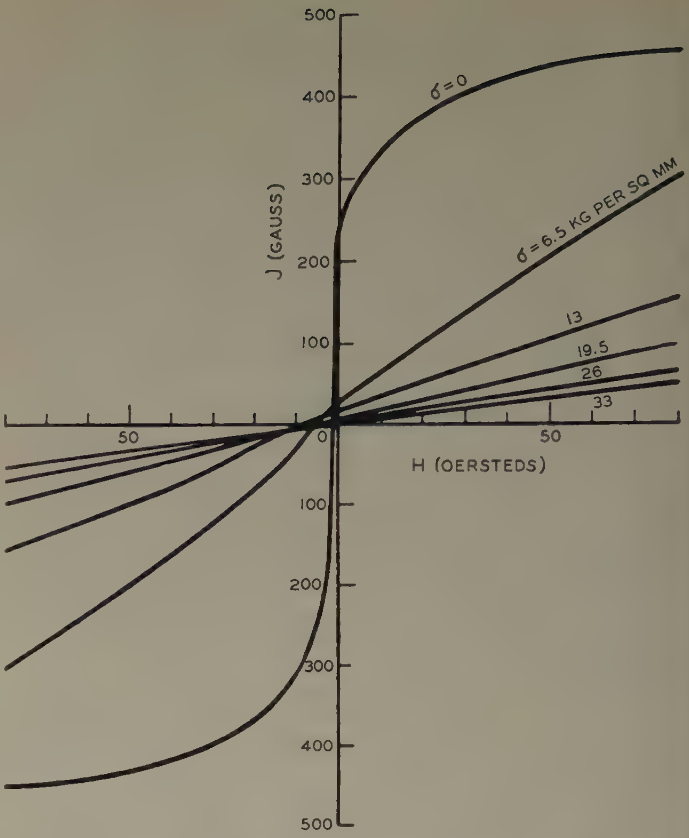


Figure 5. Hysteresis loops of annealed nickel rod under tension
Only upper half of loop shown

where

$\left(\frac{\Delta l}{l}\right)_s$ = saturation magnetostriction

σ = stress (dynes per square centimeter)

From this calculation it is seen that stress effects cannot be as important in iron as in nickel in determining preferred directions.

It should be pointed out that regardless of whether or not external stress is applied to a magnetostrictive material, stress effects are always present. These are the result of inner magnetostrictive strains which come about as follows: when a magnetic material is cooled below its Curie point, domains are formed and with them magnetostriction sets in so that the dimensions of a microcrystal occupied by a domain before and after its formation are different. This relative change in length $(\Delta L/L)_s$ produces a stress according to Young's modulus of $(\Delta L/L)_s E$ and we have a stress energy proportional to $(\Delta L/L)_s{}^2 E$ that vies with the crystal energy in determining the preferred direction. Thus no matter how perfectly annealed a magnetic material is, there always will be local stresses throughout it varying randomly in direction. These, as discussed by Kersten,[13] play an important part in determining the initial permeability of a material.

Engineering Aspects of Magnetostriction Devices

EQUIVALENT CIRCUIT OF MAGNETOSTRICTION TRANSDUCER

To present an idea of what transducer elements look like, Figure 9 shows some of the various ways in which their com-

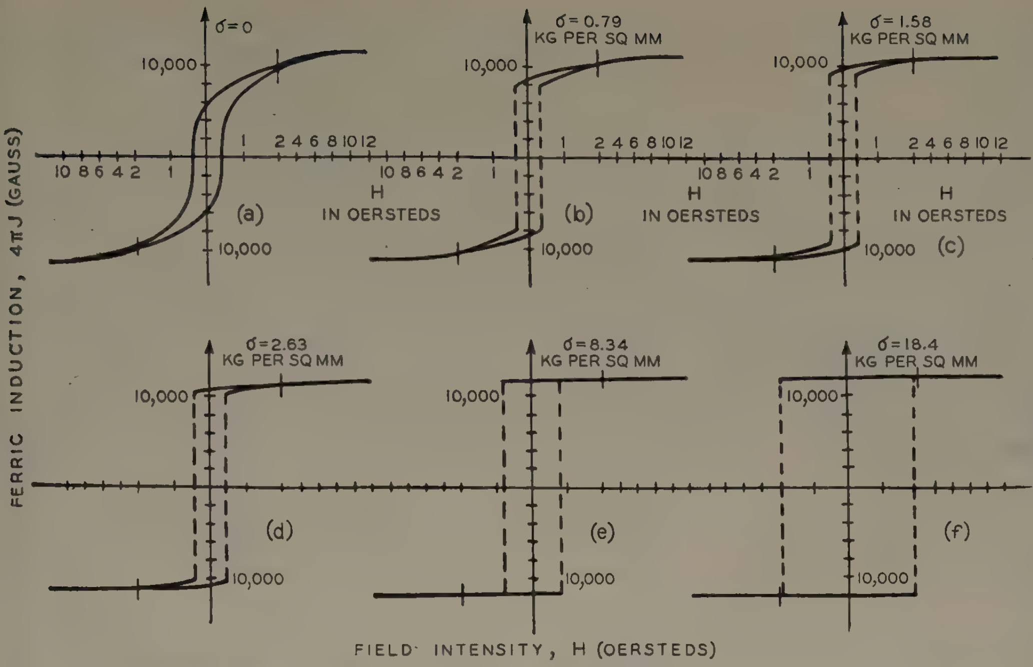


Figure 6. Hysteresis loops of permalloy (78.5 per cent nickel, 21.5 per cent iron) under tension

ponents can be arranged. The consolidated tape scroll form shown in the lower left of the figure is the invention of Williams, Nesbitt, and Goertz of the Bell Telephone Laboratories. Magnetic polarization is supplied by operating the device on residual magnetization, by a permanent magnet, or by a field supplied by a bias current through the driving coil indicated. In the models shown, acoustic power is produced by passing alternating current through the driving coils. The alternating flux produced in the magnetostrictive core changes the dimensions of the core so that if the whole transducer is immersed in some fluid, it will send out acoustic waves. On the other hand, mechanical energy is transformed into electric energy by strain of the core by pressure waves which produce a change of core flux which in turn induces a voltage in the driving coil.

The factors determining the operation of a magnetostriction transducer may be visualized most readily from an equivalent circuit of that device. To get some idea of what electrical characteristics such a circuit must display, let us examine the curves in Figure 10 and see how the components of impedance at the electric terminals of a toroidal transducer vary with frequency.* This core shape is chosen because lumped mechanical constants may be used.

In the region of mechanical resonance the inductance in *A* and the resistance in *B* both change very sharply. The inductance actually goes through zero and becomes capacitive under proper conditions. Part *C* shows the motional impedance circle of the same transducer—a plot familiar to those working with electromechanical devices having magnetic coupling of some sort. Part *D* shows the configuration of an all-electric circuit that will show the same type of impedance variation as those shown in *A*, *B*, and *C*. The parallel capacitor-resistor-inductance combination at the lower right of this circuit has a high *Q*. Perhaps the following considerations may make this analogue seem reasonable. Visualize the curve shown in *C* as being the locus of a vector which is the total impedance of the transducer; this vector is the sum of two impedances. The first impedance, consisting of the series inductance and resistance at the top of the circuit, is the result of the fact that we have an inductive coil with a magnetic core in which there are eddy currents and hysteresis. The locus of this impedance is called the clamped impedance: it is the impedance that would be obtained if the core could be clamped perfectly so as to allow no vibration. The locus of this vector alone gives the smoothly rising line that is tangent to the circle in *C*. This circle in turn is obtained by plotting the locus of the second impedance consisting of the parallel capacitor-resistor-inductance combination at the lower right. This impedance, the result of the motion of the ring, is called the motional impedance.

It is now profitable to convert this all-electric analogue into an electromechanical analogue. Although this results in a separation of electrical and mechanical quantities only on paper, it is easier thereby to visualize the separate actions of electric and mechanical circuit components.*

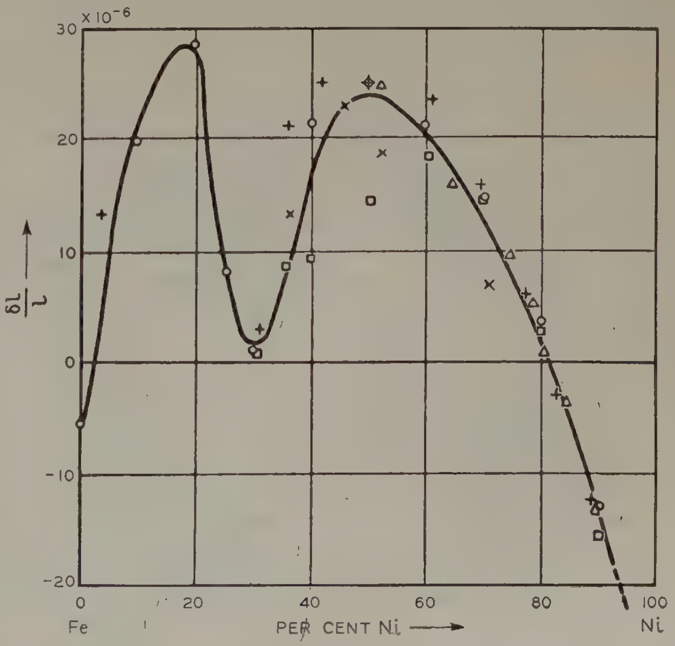


Figure 7. Saturation magnetostriction of polycrystalline nickel-iron alloys

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* To point up the marked variations of electrical impedance of a transducer as a function of frequency, the curves of Figure 10 were taken in air using as a transducer a carefully supported consolidated, laminated nickel ring wound with a driving coil that did not touch the ring. A transducer operating under actual conditions with a mechanical load will show much less marked impedance variations in the neighborhood of mechanical resonance.

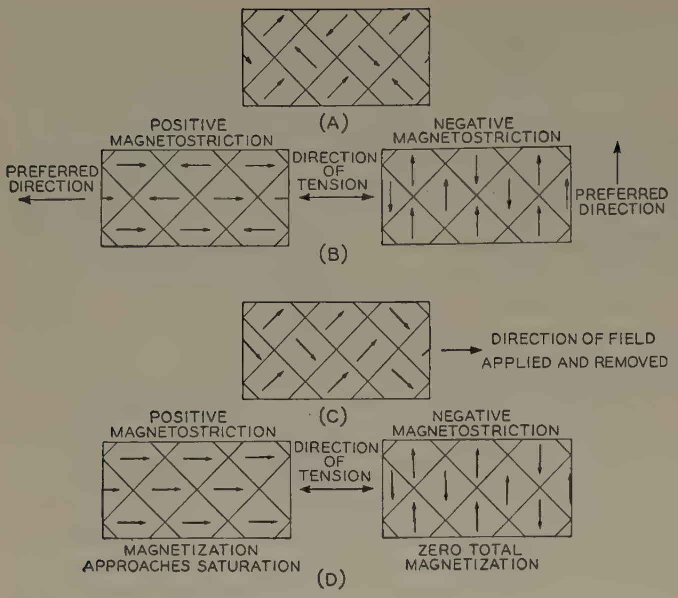
(A)
POSITIVE MAGNETOSTRICTION
NEGATIVE MAGNETOSTRICTION
PREFERRED DIRECTION
DIRECTION OF TENSION
PREFERRED DIRECTION
(B)
DIRECTION OF FIELD APPLIED AND REMOVED
POSITIVE MAGNETOSTRICTION
(C)
NEGATIVE MAGNETOSTRICTION
DIRECTION OF TENSION
MAGNETIZATION APPROACHES SATURATION
(D)
ZERO TOTAL MAGNETIZATION

Figure 8. Schematic domain picture of materials of low anisotropy under stress

A—Demagnetized—no applied field, no applied stress
B—Large applied tension, no applied field, zero total magnetization
C—Large field applied to demagnetized specimen and removed
D—Large applied tension, no applied field

The circuit of Figure 11 makes use of Firestone's mobility analogue[15,16] for the mechanical side and an ideal transformer to couple the electrical to the mechanical side, thus making possible a physically realizable electromechanical network. The analogues that are used are indicated in the figure. It is of interest to note that the equivalent circuit obtained by the mobility analogue is the dual of that obtained by the "classical" analogue in which current is analogous to velocity, voltage is analogous to force, and so forth.

Let us first examine the circuit for the case in which the transducer is operating unloaded, hence D_L in the circuit is omitted. Here current flows through the primary and force through the secondary of the ideal transformer. The turns radio T of this transformer is the force factor of the system, the force per unit current. Because there are eddy currents and hysteresis in the magnetostrictive core, T is complex. By proper design, however, the phase angle of T can be reduced to a negligible amount. Note that reflection of the mechanical over into the electrical side gives the same circuit configuration as that of Figure 10. It is now possible by purely electrical measurements, such as those given in Figure 10, combined with a few mechanical constants, such as the weight of the transducer, to evaluate completely the magnetomechanical constants used in the equivalent circuit. This method also can be used to obtain fundamental constants of magnetostriction materials.[7]

With the evaluation of circuit components of the transducer alone, the efficiency of the transducer in converting electric to mechanical energy may be computed from the equivalent circuit by adding the conductance load D_L in parallel to the other components on the mechanical side, as shown in Figure 11.

If, instead of a known voltage or current source producing acoustic power, we have a known force or velocity generator putting mechanical power into the ring, we may find in analogous manner the efficiency of conversion of acoustic to electric energy. This is done by placing the generator, with its appropriate shunt or series impedance, in parallel

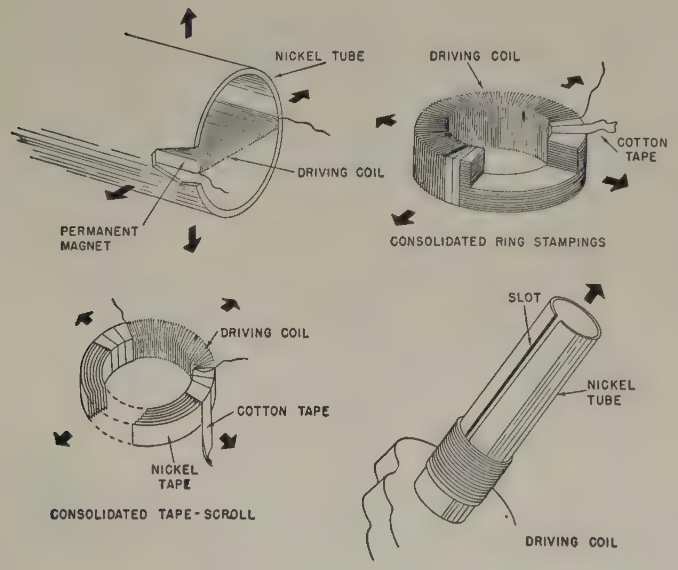

Figure 9. Arrangement of components in various magnetostriction transducers

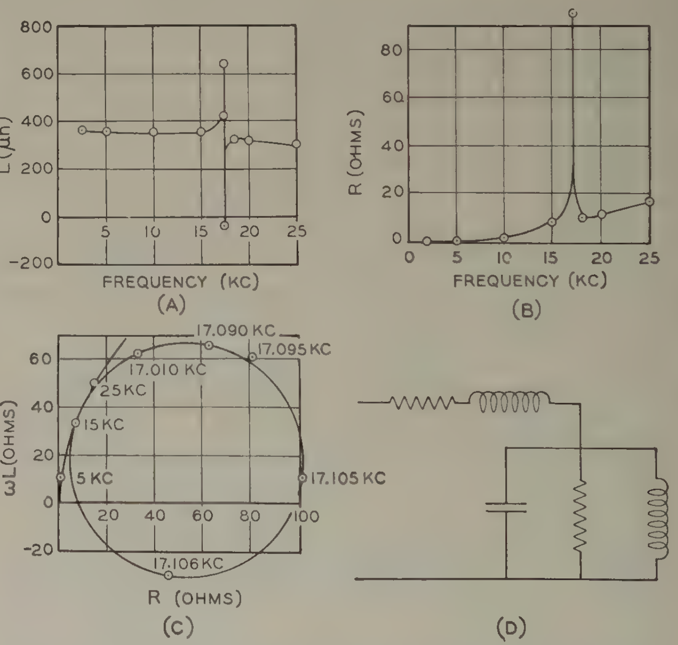

Figure 10. Electrical characteristics of magnetostriction transducer

A, B—Variation of electrical parameters of a magnetostriction transducer with frequency
C—Motional impedance circle
D—Pure electric circuit having same characteristics

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[*] The classic paper on the determination of magnetomechanical constants of a magnetostriction oscillator is that given by Butterworth and Smith.[14] Most of the analyses that have been made of magnetostriction transducers base their method of attack on that paper as does the present article.

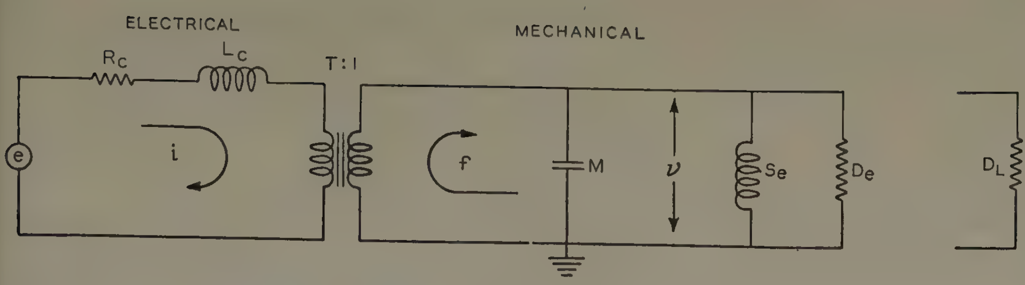

Figure 11. **Electromechanical analogue for toroidal magnetostriction transducer**

Force $(f) \sim$ *current* (i)
Velocity $(v) \sim$ *voltage* (v)
Mass $(M) \sim$ *capacitance* (C)
Effective damping $(D_e) \sim$ *conductance* (G)

$$D_e = \text{inelastic damping } (D) + \frac{2\pi\lambda T_2}{\omega N}$$

$D_L =$ *load damping*
Effective stiffness $(S_e) \sim$ *inverse self-inductance* (Γ)

$$S_e = \frac{2\pi AE}{r} - \frac{2\pi\lambda T_1}{N}$$

($E =$ *Young's modulus*)
$L_c =$ *inductance of winding if core not allowed to vibrate*
$R_c =$ *a-c resistance of winding if core not allowed to vibrate*
T (*turns ratio of ideal transformer*) = *force per unit current* $= T_1 - jT_2 =$

$$\frac{4\pi NA\lambda\mu_0 X}{r} \text{ in cgs emu system}$$

Where
$N =$ *number of turns of wire on magnetostrictive core*
$A =$ *cross sectional area of core*
$\lambda =$ *magnetostriction constant of material* $(\sigma = B\lambda)$
$\mu_0 =$ *reversible permeability at zero frequency*
$X =$ *eddy current factor*
$r =$ *mean radius of ring*

with the mechanical elements of the circuit and by placing an electric load across the terminals on the electrical side. For example, the transducer acted upon by pressure waves in the water sees a force generator with a shunt impedance D_L, the same impedance that loads the transducer when it is sending acoustic power into the water.

Calculations made on the basis of laboratory measurements show that a carefully mounted transducer with proper loading exhibits well over 90 per cent efficiency of conversion of electric to mechanical energy. However, in practice, when the whole consolidated assembly of core, tape and winding is mounted into an actual housing and mechanically loaded its efficiency falls off considerably. The table in Figure 12 gives constants taken from a consolidated stack of nickel rings and the calculated efficiency of the device working into a sea water load and working into an ideal electric load.

GENERAL DESIGN CONSIDERATIONS

This article closes with a few general remarks about some of the requirements that have to be considered in design of transducer elements, that is, the components consisting of core, driving coil, and polarizing means if separate. The need for magnetic polarization has been mentioned before. Not only is it important that polarization be provided, but that the right amount be used so as to operate on the proper point of the magnetization curve. This is so because the value of λ is determined by the material and the point at which it operates on the magnetization curve. In general, λ should be as large as possible.

Thin laminations should be used wherever possible, not only to reduce eddy losses, which are important at the ultrasonic frequencies at which most magnetostriction oscillators operate, but also to improve the force factor T. With thin laminations proper consolidation is needed to supress modes of vibration other than the fundamental, or, to put it another way, to see that the ring vibrates as a unit. Con-

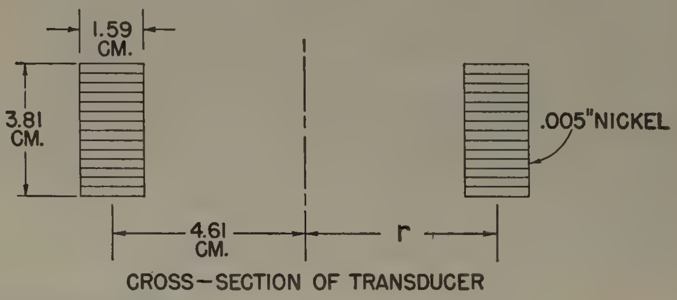

Figure 12. **Conversion efficiency of ring transducer**

Mechanical constants:
$D_L =$ *conductance of sea water load*
$= A\rho C$ *where:* $A =$ *area on which load acts*
$= 1.97 \times 10^7$
$\rho =$ *density of water*
$C =$ *velocity of sound in load*
$\rho C = 1.55 \times 10^5$ (*sea water*)
$D_e = 2.25 \times 10^6$
$\lambda = 1.34 \times 10^4$
$M = 1{,}380$ *grams*
$F = 16.26$ *kc, frequency of mechanical resonance* (M *resonates with* S_e)

(*A*) *Conversion efficiency* $= \dfrac{\text{power output to load}}{\text{power input to transducer}}$

(*B*) *Conversion efficiency* (*electric to mechanical energy—conductive mechanical load*)

$$Eff_{em} = \frac{D_L}{R_c\left[(D_L + D_e)^2 + \left(M\omega - \frac{S_e}{\omega}\right)^2\right] / T^2 + D_L + D_e}$$

Eff_{em} (*at mechanical resonance*) $= 70$ *per cent—using constants of above ring*

(*C*) *Conversion efficiency* (*mechanical to electric energy—ideal electric load*)
Assumptions: ideal electric load (*detector impedance is complex conjugate of source impedance it sees—condition for maximum power transfer*), $X = 1$, D_L *is real and operation at mechanical resonance*

$$Eff_{me} = \frac{R_c + T^2/(D_L + D_e)}{D_e[2R_c + T^2/(D_L + D_e)]^2/T^2 + 2R_c + T^2/(D_L + D_e)}$$

$= 71$ *per cent using constants of above ring*

Electrical constants:
$R_c = 7.0 \times 10^{10}$
$N = 194$
Polarizing current = *two amperes*
$T = 2.33 \times 10^9$
$\mu = 54.8$
$X = 1$
Note: cgs—em units used

solidation should include the driving coil and insulating tape surrounding the core. Leakage losses should be reduced by using a closed magnetic circuit and proper configuration of the core.

The value of inelastic damping lumps together a variety of phenomena that produce mechanical hysteresis. In choosing a core material attention should be paid to having the conductance of the inelastic damping small compared with the load, so that most of the energy is dissipated in the load.

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Fifth Shasta Turbine

Three cranes were used to lift this 360,000-pound welded-construction spiral casing and speed ring for the fifth Shasta dam hydraulic turbine to a 40-foot boring mill in the Allis-Chalmers shops. This casing measures 50 feet across. It is constructed in seven sections with riveted buttstrap joints. Its speed ring portion has an 18-foot inside diameter. The inlet section has an inside diameter of 12 feet 8 inches, and is made of $1^7/_8$-inch plates. Upon completion the unit will be shipped to join four other Allis-Chalmers turbines at Shasta. Each of these is rated 103,000 horsepower at $138^1/_2$ rpm under a 330-foot head.

International Radiotelegraph Communications

SIDNEY SPARKS

MOST OF THE major problems confronting the radiotelegraph industry in the United States, and in varying degrees elsewhere, arise from the following basic causes:

1. Competition by increasingly efficient overseas airmail and telephone services.
2. Rising labor costs without proportionate increase in productivity.
3. Scarcity of suitable frequencies.
4. Trend toward lower rates.

Traditional methods of operation, and existing services, have been developed approximately to their maximum possibilities, and are inadequate to meet present requirements. A new approach is necessary on a basis to permit the handling of larger volumes of traffic at lower unit cost and with reduced requirement for radio frequencies. Printing telegraph tape relay methods are being used effectively as one means of increasing operating efficiency, reducing costs, and conserving frequencies.

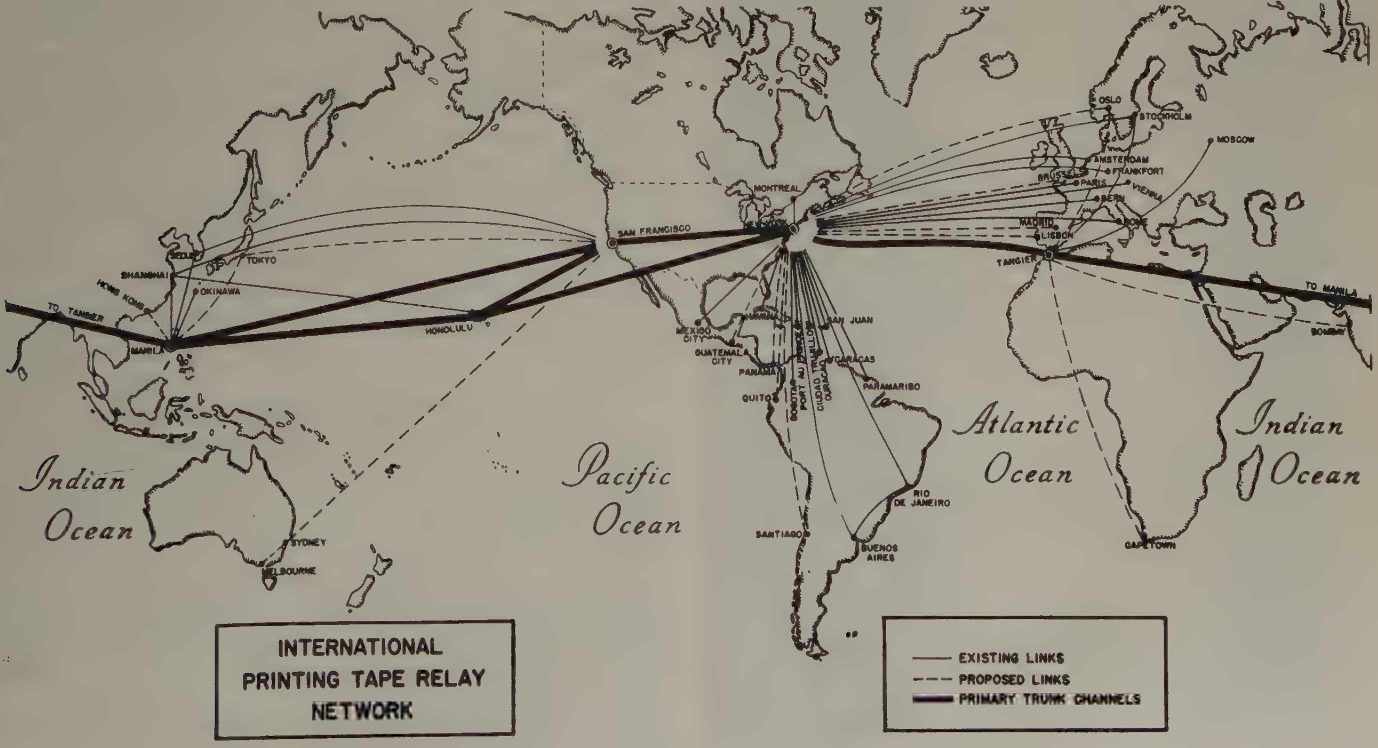
In a printing tape relay system messages are received in the form of characters simultaneously printed on and perforated in code combinations in strips of tape from which retransmission may be effected by mechanical means.

By eliminating manual reprocessing at relay points faster, more accurate service and lower cost per message handled are the advantages gained. The printing tape relay method, by enabling the ultimate user to do his own processing, and by facilitating fast and economical relay of traffic, permits new services to be offered on an international basis which have proved to be of great value in domestic service in the United States and elsewhere. By removing the major disadvantages of relaying traffic, incentives for maintenance of direct circuits are minimized. The ultimate effect of this may be to reduce materially the requirements for frequencies.

The links thus far placed in operation and projected in the international printing tape relay network are shown in Figure 1. The heavy line girdling the earth through Manila, Honolulu, San Francisco, New York, and Tangier is a multichannel trunk that is used as a regular route for traffic between points so far separated that direct working is difficult, and for alternate routing of traffic when regular routes are interrupted or congested.

The network shown in Figure 1 is focused on the United States, but it should not be deduced from this that it is intended to be limited to American links. It increasingly will become a world network as compatible links are placed in service between terminals in other countries that presently are connected by Morse and other types of circuits not adapted to tape relay requirements.

Figure 1. The international printing tape relay network



Digest of paper **48-131,** "International Radiotelegraph Communications," recommended by the AIEE communication committee and approved by the AIEE technical program committee for presentation at the AIEE summer general meeting, Mexico, Federal District, Mexico, June 21–25, 1948. Not scheduled for publication in AIEE *TRANSACTIONS*.

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New Oil-Filled Apparatus Bushings

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FOR 32 YEARS, oil-filled bushings have been applied to transformers and oil circuit breakers. Although these bushings have an excellent service record, recent trends in electric apparatus have made improvements necessary. A new line of oil-filled bushings has been developed which meets the requirements of hermetic sealing, low-cost maintenance, high mechanical strength, reduction in size and weight, and also provides ease of installation and storage. These bushings meet AIEE and NEMA (National Electrical Manufacturers Association) standards and are designed to meet the needs of modern apparatus.

ADVANTAGES OF THE NEW CONSTRUCTION

The hermetic sealed construction is accomplished by center-clamping and by the use of synthetic rubber gaskets. The sealed construction has been thoroughly service-tested in approximately 100,000 moderate-voltage bushings over the past 16 years. Low-cost maintenance also is obtained by hermetic sealing which maintains the initial high dielectric strength of the internal insulation throughout the years of service. High mechanical strength results from center-clamping and the new bushings have withstood severe mechanical loadings under static conditions and also under interrupting tests applied to oil circuit breakers.

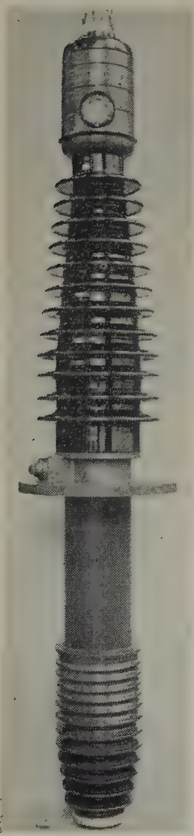

Figure 1 (left). A 138-kv capacitance bushing for oil circuit breaker service

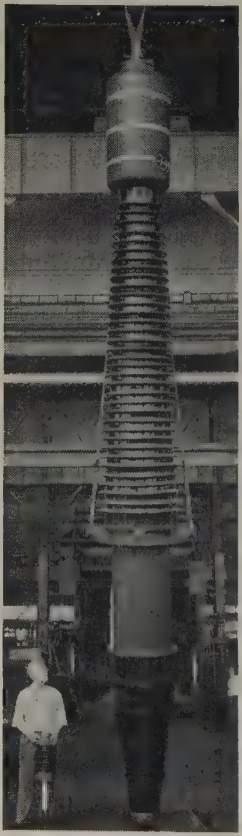

Figure 2 (right). A 360-kv capacitance bushing for transformer service

Reduction in diameter has been obtained by the center-clamped construction which requires no cemented-on clamping rings and by adjustment of internal insulation stresses to obtain maximum efficiency of the dielectric structure. The reduced diameter permits the use of smaller bushing type of current transformers, the elimination of mounting adapters, and less complicated apparatus covers. Installation requires no special equipment.

APPLICATION

The new bushing is available, with or without the capacitance tap feature, for application to transformers in voltage ratings from 92 kv to 360 kv and to oil circuit breakers in ratings from 115 kv to 196 kv. Standard bushings for oil circuit breakers are equipped with the capacitance tap which is also standard for transformer bushings rated 196 kv and above.

Bushings in ratings from 115 kv to 230 kv have mounting flanges which are interchangeable with the superseded bushings. The elimination of the bottom clamping ring has permitted shortening the bushings approximately three inches. For replacements in oil circuit breakers, a suitable adapter is used to compensate for the shortened length. Bushings in the foregoing ratings for transformers which have detachable cable terminal parts may be interchanged with the old bushings having the same ground sleeve length, because the terminal studs brazed to the transformer leads are interchangeable. Differences in height between the old and new bushings in some instances may require changing cable lead lengths. Typical applications of the new bushing are shown in Figures 1 and 2.

Principal features of the new bushing are

1. Bushing is center-clamped, placing porcelain parts under compression—under which stress porcelain is strongest.
2. Gaskets at ends of porcelain shells are confined in recesses of proper depth to insure pressure-tight joints without metal-to-porcelain contact.
3. High-pressure multicoil spring assembly maintains safe pressure on gasketed joints under all conditions of operation.
4. All gaskets are of synthetic rubber which is oilproof and waterproof, and retains its resiliency under all expected conditions of service.
5. Internal insulation is of oil-permeable barriers and oil ducts in combination, insuring high dielectric strength under testing and operating voltages.
6. Excepting the dome, all castings have been eliminated. High-strength brass forgings have replaced the castings in all nonmagnetic parts.

Digest of paper **48-174**, "A New Line of Oil-Filled Apparatus Bushings," recommended by the AIEE switchgear and transformer committees and approved by the AIEE technical program committee for presentation at the AIEE North Eastern District meeting, New Haven, Conn., April 28–30, 1948. Scheduled for publication in AIEE *TRANSACTIONS*, volume 67, 1948.

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Cascades Used in Isotope Separation

HAROLD C. UREY

Although there are eight methods for separating desired isotopes, each demand cannot be met by all eight processes. The engineer must be able not only to determine which methods are applicable, but also to calculate the separation, volume, and time involved in any type process. This is the seventh of a series of articles developed by the AIEE nucleonics committee; the entire series will be published in pamphlet form upon its completion.

WORLD WAR II emphasized the necessity for evaluating more systematically two problems before planning a plant for isotope separation—cost and equilibrium time. The various methods, as well as considerations involved and the general kind of results expected, were discussed in the preceding article of this series.[1]

A STATEMENT OF THE GENERAL PROBLEM

As in all processing problems, it is essential to consider from the very beginning certain elementary questions. The problem of the separation of isotopes is no longer primarily a scientific one, but rather is economic. It has no particular scientific interest to us any more to demonstrate that the atomic weight of an element can be changed by the separation of its isotopes, though this was once a very interesting scientific question. It remains to select, for a given separation problem, the most suitable method from the list.

1. Electromagnetic process.
2. Gaseous diffusion process.
3. Thermal diffusion process.
4. Ion mobility method.
5. Centrifuge.
6. Fractional distillation.
7. Chemical exchange process.
8. Electrolysis.

To make such a selection it is first necessary to consider the amounts and concentrations desired as well as the particular elements whose separation is desired. Highly purified isotopes may be desired, as for example for such purposes as the study of the nuclear properties of these individual types of atoms. In this instance relatively small amounts of the isotopes will be needed but high purity will be essential. However, it may be desired to separate the uranium isotope of mass 235 in large quantities in order to produce atomic bombs. In this instance, a considerable concentration of the isotope is needed, and its production in large quantities is important. Again, it may be that high purity of the separated isotope is not important, as for example in the preparation of stable isotopic tracers such as nitrogen (${}_7N^{15}$), but in this instance a considerable production is needed, of the order of grams per day, of perhaps 50 per cent or higher concentration. Or again, it may be desired to produce deuterium oxide of very high purity and in very substantial amounts. Or, it may be desired to concentrate an isotope as a part of a testing procedure in which only small amounts of materials are desired; a recent problem of this kind is the concentration of ${}_6C^{14}$ from natural sources of carbon in order to establish the age of samples of carbon.

As to the choice of method which will be made in any of these instances, there are two ultimate criteria which must be stressed. In the first place, there is the cost of plant and operation. This of course is the criterion for most industrial processes. It is necessary, however, to emphasize another factor in isotope separation, namely, the time required to get the apparatus in operation. This may be substantial and may vitiate what otherwise would be an acceptable process.

Because of these considerations, it is necessary to estimate from the very beginning what the probable size of plant will be and how long it will take the plant to come to equilibrium. It is often possible on the basis of the most elementary scientific theory to eliminate certain processes from all consideration, and in some instances, for example the electromagnetic method, when only small amounts of material are desired for experimental work and the cost is not an important factor, extensive considerations are not necessary. However, without proper study it is entirely possible to plan isotope separation plants which even a major war could not justify, and which would require such long periods of time to get into operation that the people who started construction would be gathered to their fathers before production finally began.

THE THEORY OF CASCADES

For a few processes it may be unnecessary to consider how best to bring together individual units to secure a large over-all separation. This is particularly true of the electrolytic and the electromagnetic processes. In all other instances it is vital that minimum size of plant to accomplish a given production and over-all separation be estimated. Hence this discussion of cascades. There are two types of cascades to be considered: those which make use of cascades of simple separation units, and those which make use of cascades of columns. Simple separation units will be considered first.

Assume a process for the separation of isotopes which can be constructed into a separate unit such that material of some initial composition flows to this unit and is separated into two fractions, the one containing an increased

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concentration of the lighter isotope and the other an increased concentration of the heavier isotope. A simple diagram of such a separation unit is presented in Figure 1, together with the symbols which we shall use to designate flows and concentrations. The question is how to arrange such flows in a cascade of units in such a way as to use the minimum amount of total flow of material and the minimum amount of apparatus in the whole process. Of course the cost of construction and operation, which is a different problem, is of interest but its solution cannot be discussed in general, but must be considered for a specific process because of the dependence upon type of material and type of separation unit.

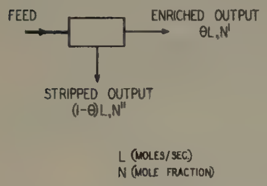

Figure 1. Simple diagram of a separation unit

L—Moles per second
N—Mole fraction

Figure 2 shows a cascade of units of this type, together with the symbols for the flows and mole fractions. The fraction of the feed which is delivered to the light fraction is designated by θ_s. The ratio of the light isotope to the heavy isotope in the light fraction divided by the ratio of these two isotopes in the feed to a unit will be designated by α, and will be called the simple process fractionation factor. The values of the θ_s's, the flows L_s in terms of the ordinal number of the stage s, the value of α, and the mole fraction in the feed material N_s and in the product N_s', and the total amount of product produced P, in this cascade determine its effectiveness. This is not fundamentally a difficult problem, but it is somewhat troublesome. It has been solved by Doctor Karl Cohen and by Doctor Peierles independently, and extended in many details by others, notably Doctor M. Benedict. I shall not give the complete solution, which is long and rather intricate, but shall state the conditions and the results of the calculations. The total amount of material entering a unit must be equal to the total amount of material that leaves; and the total amount of one constituent, say the light constituent, entering must be equal to the total amount of the light constituent leaving. If a transverse line (*AB* in Figure 2) is drawn, the difference in the flows in the two streams crossing this line at each stage of the process must be equal to the total amount of material withdrawn as product, and the difference in the flows of the light constituent also must be equal to the amount of the light constituent withdrawn from the cascade. In order that the cascade shall be as efficient as possible, no mixing must occur at any point where the streams join, for if mixing occurs additional work must be done to unmix the material again. Hence this gives additional conditions in regard to the mole fractions of the feed material to the units and the fractions produced by other units at the point where they join. With these conditions there are sufficient equations to solve for the desired quantities. The results of the solutions are

$$\theta_s=\frac{1+\alpha\dfrac{N_s}{1-N_s}}{(\alpha+1)\left(1+\dfrac{N_s}{1-N_s}\right)} \tag{1}$$

$$L_s=\frac{P(\alpha+1)(N_P-N_s)}{(\alpha-1)N_s(1-N_s)} \tag{2}$$

$$\begin{aligned}\text{Total flow}=\sum_0^s L_s=\frac{\alpha+1}{\alpha-1}P\left\{\frac{2N_P-1}{\log_\epsilon\alpha}\log_\epsilon\frac{N_P}{1-N_P}\Big/\frac{N_0}{1-N_0}+\right.\\ \left.\frac{\alpha-(\alpha+1)N_0}{\alpha-1}\times\frac{N_P-N_0}{N_0(1-N_0)}\right\}\approx\frac{2P}{(\alpha-1)^2}\left\{(2N_P-1)\times\right.\\ \left.\log_\epsilon\frac{N_P}{1-N_P}\Big/\left[\frac{N_0}{1-N_0}+\frac{(1-2N_0)(N_P-N_0)}{N_0(1-N_s)}\right]\right\}\end{aligned} \tag{3}$$

$$S=\frac{\log_\epsilon\dfrac{N_P}{1-N_P}\Big/\dfrac{N_0}{1-N_0}}{\log_\epsilon\alpha} \tag{4}$$

where s is the total number of stages.

Table I lists calculated flows as a function of the mole fraction of the desired constituent in a cascade. It will be seen that at the point where there is a high concentration the flow is small, and hence the units may be small, while at the feed point where the concentration is low the required sizes are large, and in fact that most of the plant is required to double the concentrations. The total flow also can be calculated by summing the flows to each of the units, and the result of this is a quantity which is then proportional to the size of the entire cascade. It is not possible to build cascades of this kind with smaller total flow than that given by this equation. These equations are valuable because they tell the minimum size of plant which could be constructed.

Modifications of these equations must be taken into account if there are leaks in the apparatus being used, but if estimates can be made of the probable leak in an apparatus it is possible to secure approximate solutions to the equations.

In separating isotopes by methods which involve small values of α, the time required to come to equilibrium is a very important consideration. It easily can happen that the amount of material in a cascade is so large that this time is very long. Exact solutions to this problem can be secured, but for the purpose of this discussion it only need be noted that this time will depend upon the amount of the desired constituent stored in the apparatus over and above the amount in the original material fed to the plant. If the plant is designed to produce PN_P moles per day, then an approximate value for the time required for equilibrium is secured by dividing the total stored desired constituent

Table I. Calculated Flows in a Simple Unit as a Function of the Mole Fraction of the Desired Constituent

$N_s/1-N_s$	0.01	0.02	0.04	0.08	0.16	0.32	0.64	6	7	8	8.5	9
N_s	0.01	0.02	0.038	0.074	0.14	0.24	0.39	0.86	0.875	0.888	0.895	0.90
$\frac{N_P-N_s}{N_s(1-N_s)}$	90.8	45.8	23.3	12.3	6.4	3.6	2.1	0.35	0.22	0.11	0.056	0

by the rate of production for which the plant is designed. This calculated length of time is not exact but by this means it can be shown whether or not the length of time required for equilibrium is not prohibitive.

It will be noted that the total flow to the plant given in equation 3 consists of two parts; first a factor that depends only upon the rate of production of the plant and the efficiency of the individual units, namely, upon the α for the units; and a second factor that depends upon the mole fractions of the feed and product, and also upon the fractionation factor α. However, if α is nearly equal to 1, the dependence of this second factor on α is not great, and a good approximation is secured by setting α equal to 1 in that factor. When this is done it is obvious that the size of the ideal plant is determined by two factors, the one depending upon the construction of the units and the other upon the concentration of the desired isotope in the initial feed and in the product to be secured. Thus all efforts at improving the process must be directed toward the improvement of the fractionation factor α, which should be as different from unity as possible, and to the improvement of the flow, say G, which can be accomplished in an apparatus of unit size. To minimize the total flow and thus secure a minimum size of plant it is necessary to make $\dfrac{1}{G(\alpha-1)^2}$ a minimum. Improving the flows at too great an expense to the α or improving α at too great a cost in terms of flows per unit area, or volume, or other criteria, will increase the entire size of the plant.

Of course no actual plant of this kind would be built in this fashion, for it is necessary according to our calculations to have a large number of units all differing from each other, and this would mean an enormous amount of work in designing, testing, building, and adjusting all of these various units. What must be done is to build a section of the plant out of one size of unit and the next section out of a somewhat larger size, and so forth. In other words a squared off plant must be used. These equations, of course, do not apply to such a plant. There is mixing where the flows join, and over one section of the cascade the flows L_s and θ_s are constant. In this instance it is possible to set up equations for these sections.

Of particular interest is the case where α is very nearly equal to 1, so that only a small change is made from stage to stage, for in this case it is possible to substitute a differential equation for the difference equations which must be used when α is appreciably different from unity. The differential equation secured is as follows:

$$\frac{dN}{ds}=-2(\alpha-1)\left\{\frac{P}{(\alpha-1)L}N_P-\left(1+\frac{P}{(\alpha-1)L}\right)N+N^2\right\} \tag{5}$$

The handling of these equations will not be discussed until later, as it is found that the differential equations for other important methods for separating isotopes have precisely the same form and the whole problem of constructing squared off cascades is essentially the same no matter what method is used.

The form of the cascade developed in this section is applicable to the electrolytic separation of the hydrogen isotopes, the electromagnetic separation of isotopes, and the diffusion separation.

CASCADES OF COLUMNS

In the chemical separation of isotopes, including the use of distillation and exchange reactions, the thermal diffusion separation of isotopes, and the reflux centrifuge, it is possible to make cascades which are from the beginning of the squared off type, and it is not convenient to construct cascades consisting of units in each of which one elementary process is carried out. To develop equations for this type of operation, the distillation or chemical exchange column is considered. This operates on two phases, a liquid and a gas, and depends for its effectiveness upon a fractionation which occurs between the two phases. Such distillation columns usually are handled in the chemical industry by means of equivalent theoretical plates, but because very large numbers of theoretical plates are needed for these processes it is desirable to develop a differential equation for the process. This can be done quite easily, at least to the same precision as the usual chemical engineering methods of handling such problems. The essential equations for such processes were developed some years ago by Doctor Cohen in connection with the exchange method for the separation of isotopes. The following differential equations can be set up for the two phases, in which capital letters are used to designate concentrations and flows in that phase where the desired isotope concentrates preferentially, and small letters for the corresponding quantities for that phase in which the desired isotope is displaced. We also can define α as the ratio of the desired isotope to the other in that phase in which the desired isotope preferentially concentrates, divided by a similar ratio for the other phase,

$$\alpha=\frac{N}{1-N}\bigg/\frac{n}{1-n}$$

(It is to be noted that this α is not identical with the one used in the preceding section.) The two differential equations in which time dependent terms are included become

$$H\frac{\partial N}{\partial t}+L\frac{\partial N}{\partial z}-k\{N(1-n)-\alpha n(1-N)\}=0,$$

$$h\frac{\partial n}{\partial t}-l\frac{\partial n}{\partial z}+k\{N(1-n)-\alpha n(1-N)\}=0,$$

where H and h are the holdup per unit length in the two phases, z is the distance along the column measured from the end where the desired constituent has the lower concentration, n and N are mole fractions of the desired constituent and k is a constant which determines the rate of exchange between the two phases.

The time that is required for the system to come to equilibrium is very important indeed, for it easily can happen that long periods may be involved, but it is also possible to secure approximate values for this time by a method similar to that described in the previous section, namely, to calculate the concentration throughout the system for the steady operating condition, sum the concentrations of the desired constituent in the entire apparatus, and divide by the rate of production per unit time. Hence the time will not be considered a dependent function of these equations. Setting, therefore, the rate of change of the mole fraction with respect to the time equal to zero, two equations in the length of the column z and the mole fractions $\mathcal{N}$ and n are secured. Two expressions can be given which enable us to eliminate certain quantities from these equations. In the first place the total flow in the one phase minus the flow in the second must be equal to the total rate at which material is withdrawn, and secondly, the total flow of the desired constituent in the one phase minus the flow of this constituent in the other must be equal to the rate with which this constituent is withdrawn. The following equations express these conditions.

$$L-l=P$$
$$L\mathcal{N}-ln=P\mathcal{N}_P$$

It is then possible to eliminate, for example, the mole fraction n from these equations and secure the following equation.

$$\frac{d\mathcal{N}}{dz}=-\frac{k(\alpha-1)}{l}\{\alpha\vartheta\mathcal{N}_P-(1+\vartheta)\mathcal{N}+(\alpha-1)\vartheta\mathcal{N}_P\mathcal{N}+\mathcal{N}^2\}$$
$$\approx-\frac{k(\alpha-1)}{l}\ \{\vartheta\mathcal{N}_P-(1+\vartheta)\mathcal{N}+\mathcal{N}^2\}, \qquad (6)$$

where

$$\vartheta=\frac{P}{(\alpha-1)L}$$

It will be noted that the form of this equation is precisely the same as that derived in the preceding equation for the squared off cascade of diffusion units in which the α as used there was nearly equal to 1. In those instances in which α for the chemical separation or for distillation is nearly equal to unity it is possible to set $\alpha-1=0$, in which case the two equations are of exactly the same form.

Jones, Furry, and Ontzager developed the equations for thermal diffusion of a gas or a liquid, taking the simplified case in which the annular space between the heated and the cooled tubes is so thin as compared with its length that it may be regarded as two parallel plane surfaces. The theory of the thermal diffusion separation is rather involved and cannot be presented briefly at all. They considered several types of operation, among them the continuous withdrawal of product from one end of the thermal diffusion tube and continuous feed at another point, and withdrawal of waste at the opposite end of the tube. For this arrangement they secured the following differential equation, which has been changed in nomenclature to make it consistent with the symbols used in the rest of this article.

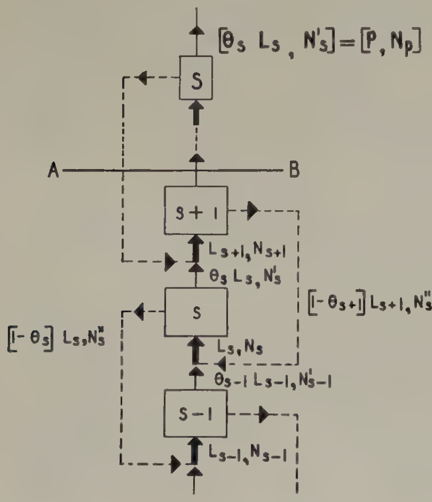
$[\theta_s\ L_s,\ N_s']=[P,\ N_p]$
S
A
B
s + 1
L_{s+1}, N_{s+1}
$\theta_s\ L_s, N_s'$
S
$[1-\theta_{s+1}]\ L_{s+1}, N_{s+1}''$
$[1-\theta_s]\ L_s, N_s''$
L_s, N_s
$\theta_{s-1}\ L_{s-1}, N_{s-1}'$
s − 1
L_{s-1}, N_{s-1}

Figure 2. Cascade of separation units

—— *Enriched fraction*
---- *Depleted fraction*
▬ *Feed*

$$\frac{d\mathcal{N}}{dz}=-2A\left\{\frac{P}{H}\mathcal{N}_P-\left(1+\frac{P}{H}\right)\mathcal{N}+\mathcal{N}^2\right\} \qquad (7)$$

In this equation the constants A and H depend upon the constants of the liquid or gas, thermal conductivity, coefficients of diffusion, coefficients of viscosity, the force of gravity, and the spacing of the tubes, as well as the thermal diffusion coefficient, which is directly responsible for the separation secured. These quantities are given in analytical form by the authors, and if all of the constants characteristic of the gas or liquid are known it should be possible to calculate these constants and construct a thermal diffusion column without empirical tests for these constants. In general this is not possible, and hence it is necessary by means of experiments to determine their value.

In the centrifuge, a centrifugal field acting upon the molecules of a gas results in a separation of the molecules of different atomic weight as between the axis and the periphery, and if the gas flows in one direction along a field near the pheriphery and in the opposite direction in the center of the centrifuge, we have again a case of countercurrent flow similar in many respects to that encountered in chemical separation and in thermal diffusion. Our problem is then to see whether it is possible to set up differential equations for this flow of a kind similar to that involved in the other types. This proves to be possible, and the differential equations take the same form as those previously given though the constants can be given only as integrals which are determined by the character of the flow distribution in the centrifuge. The differential equation has the same form as those discussed previously, but will not be further developed here.

In setting up the squared off cascades of the type considered in this section, and integrating these differential equations, we find it convenient to keep in mind a cascade such as is shown in Figure 3, in which the numbering of the sections of the cascade is indicated by the general symbol r, and in which they are numbered from the product end of the cascade toward the feed. The figure also indicates the symbols which will be used to designate flows within each of these sections and the mole fractions at the ends. Within each one of these sections the differential equations apply. Each section may consist of but one single unit of apparatus, the sections then having a different size; or it may be that each section consists of a number of units operating in parallel or in series. It is to be noted that the limits of integration for one of the sections are the concentrations at the top and bottom of this section and that the length co-ordinate is to be integrated over the length of the section (in independent separate units instead of the length $\mathcal{Z}_r$, the number of units S in the section is used). It is convenient to write all of these four equations in the form

$$\frac{d\mathcal{N}}{dz}=-\frac{2\sigma_r}{Z_r}\ \{\vartheta_r\mathcal{N}_P-(1+\vartheta_r)\mathcal{N}+\mathcal{N}^2\} \qquad (8)$$

in which Table II gives the values of the symbols in each of the three differential equations. The integration of this equation is then integrated for the r^{th} section as follows:

$$\tanh^{-1}\frac{\{N_{r-1}-N_r)\{(1-\vartheta_r)^2-4\vartheta_r N_P\}^{1/2}}{(N_{r-1}+N_r)(1+\vartheta_r)-2N_{r-1}N_r-2\vartheta_r N_P} = \sigma_r\{(1+\vartheta_r)^2-4\vartheta_r N_P\}^{1/2} \quad (9)$$

For the first section, namely that nearer the product end, the mole fraction of the product N_P is the same as the mole fraction of the product end of this section, that is

$$\begin{aligned} N_{r-1} &= N_{-1} \\ &= N_P \end{aligned}$$

but in all other cases N_P is not a limit of integration.

Next arises the question of how to design a cascade of such units. First it is necessary to determine the appropriate constants for each mode of operation by means of experiment or appropriate theory, but in all types it is likely to be necessary to determine the constants empirically. In the cascade of individual units the value of that α must be determined experimentally and the value of the flow appropriate to that α must be determined by experiment, and an attempt must be made to make $\frac{1}{G(\alpha-1)}$ a maximum. Once this relationship has been explored experimentally it is then possible to construct units of different sizes and arrangements appropriate to the scale of operations which is desired, and once the constants of such units are known the equation enables a section of a cascade of this kind to be set up. The question of choice of the number of sections in the cascade and the size of these sections must be determined by estimates of the cost of construction and operation, which will depend in each instance upon the type of process being used. Once having made an estimate of what can be done with respect to the individual units it is then possible to calculate the entire cascade in accordance with one's initial estimate of a favorable number of sections. Having done this, the next step is to estimate the total flow in such an apparatus and compare it with the ideal cascade. One sees therefore how large a sacrifice in plant size is made for the practical plant as compared with the ideal plant. In the case of the chemical separation methods it is necessary to determine the constant k, which in fact determines the number of theoretical plates required in the column. This can be done by setting up columns of different diameters and different packing materials and running them at constant reflux until the final steady state is secured. The integration of equation 8 for this specific case, namely $P=0$, gives

$$\frac{N_P}{1-N_P}\bigg/\frac{N_0}{1-N_0}=\epsilon^{2\sigma},$$

and hence the over-all concentration secured determines k for a given value of the flow of constituents through the column. Having the value of this k as a function of the flows, it is then possible to calculate the size of columns which is required for any size desired, and one proceeds to make estimates for a plant say of one, two, or three sections, and so forth; and then on the basis of cost of construction and estimated cost of operation the one that appears most favorable is selected.

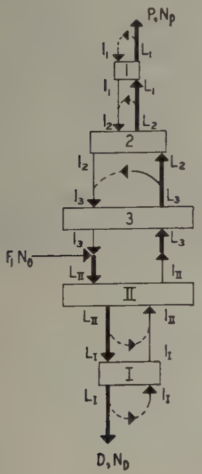

Figure 3. Diagram of squared off cascade system

In the case of the thermal diffusion separation it is necessary to determine experimentally two constants A and H. This can be done by setting up thermal diffusion columns of reasonable length and operating each one of them in two ways, one with total reflux and the other with a finite flow, and adjusting the constants A and H until the experimental data are confirmed. To select the best thermal diffusion columns it is necessary to try several types of construction until the best operating conditions are secured, and then it is again possible to make estimates on an actual plant by setting up cascades containing one, two, or more sections and selecting the one which from the standpoint of cost and operation seems most desirable. Precisely the same operation must be made in the case of the centrifuge plant. In this case some of the constants are subject to calculation. There is only one unknown constant in the equations, and that is the coefficient of diffusion, which again must be determined experimentally in one way or another.

In the preceding discussion of all of these methods it has been assumed that it was only necessary to remove from the feed material that fraction of the desired constituent which can be secured by the action of approximately one theoretical plate or one simple process separation and the waste accordingly had nearly the same composition as the feed material. This may not be the case, and in this case it is necessary to construct stripping sections. These can be handled theoretically very easily in terms of the equations which have been developed above, and it will be seen that a stripping section is identical in its operation in every way providing one merely interchanges the roles of the desired constituent and the wasted constituent. That is, in setting up our equations for the stripping sections what was previously the undesired constituent becomes the desired

Table II. Values of Symbols in Equation 8

Symbol	Diffusion	Chemical	Therma Diffusion
z	S	z	z
σ_r	$(\alpha-1)S_r$	$\frac{k_r(\alpha-1)Z_r}{2l_r}$	AZ_r
ϑ_r	$\frac{P}{(\alpha-1)L_r}$	$\frac{P}{L_r(\alpha-1)}$	$\frac{P}{H}$

constituent, and if one consistently defines all of the mole fractions and the fractionation factors in terms of this changed point of view one gets all of the equations that are required for the stripping sections of the plant in every case, and these equations need not be repeated here.

CONCLUSIONS

Certain technical aspects of the separation of isotopes and the kind of basis upon which a judgment of the best methods can be made have been discussed. I only wish to summarize briefly my own rough conclusions about the region of usefulness of these principal methods.

If one wishes to produce isotopes in small amounts for use in many purely scientific problems such as the study of nuclear reactions, the best method that can be used is the electromagnetic method now being used by the Atomic Energy Commission for the production of stable isotopes, which are being distributed to scientific workers. It may be even that certain of these isotopes can be separated by this method in substantial quantities, and if the necessity should arise for large scale production this method should certainly be considered. This method has not been discussed in detail in this article. The principles on which it operates are old and improvements in recent years have consisted of improved details for operation.

In one particular instance it is desired to concentrate carbon ($_6C^{14}$) from natural samples of carbon to determine the age of recent geological and archaeological deposits. Work on this problem is in progress under Professor Libby at the University of Chicago, Chicago, Ill. In this instance thermal diffusion is the ideal method. The apparatus is rather small, inexpensive, and easily operated. The cost of current is high per unit of isotope separated, but not so high as to be prohibitive for work of this kind. The thermal diffusion method is not particularly good for large scale production, however, because of the large power cost.

The diffusion process is used when no other better method is available and when very large production is required. About the same number of units must be present in a diffusion cascade regardless of production, and hence the problems of control and operation are much the same regardless of the size. Thus the advantage to the diffusion process is all in the direction of large scale production, but it is not intrinsically a good method as compared with chemical separation methods.

The centrifuge method has not been developed to the extent of the others, but it is probable that it would be about as effective as the diffusion process.

The chemical separation methods for those few elements for which they are used are the cheapest of all the methods discussed providing reasonable production is expected. Thus these methods are well adapted to the separation of hydrogen, boron, carbon, nitrogen, oxygen, and sulfur isotopes. The chemical effects drop off very rapidly with increased atomic weight, and hence the usefulness of chemical separation is practically nil for higher atomic weight materials.

In regard to particularly outstanding successes of these methods we might note that thermal diffusion has been used to separate isotopes of oxygen, neon, chlorine and krypton in nearly pure form. The chemical separations have been used for hydrogen, boron, carbon, nitrogen, and sulfur, and are commercial methods for the production of these isotopes. The diffusion process has been used to a certain extent on many elements, but was used very successfully for the separation of the uranium isotopes. Centrifuge methods have not been developed to a state where production of any element in high concentrations or in large amounts has been secured.

At the present time it can be stated that, if we should need any particular isotope separated badly enough, some one of the methods discussed in this article is available to carry out that separation. The problem is in fact economic and industrial, and no longer scientific. There is, of course, always the possibility that other methods may be developed for carrying out these difficult separation processes, though the field at the present time has been explored rather extensively.

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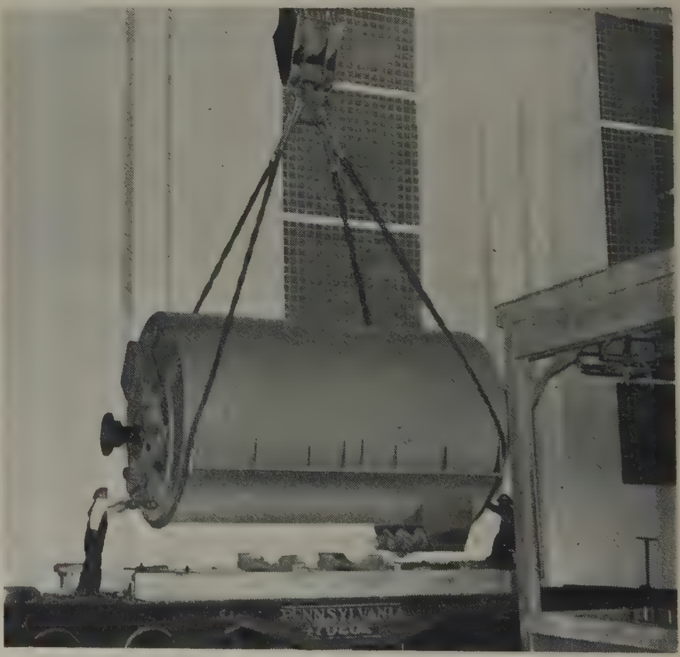
Standardized Generator Shipped With Rotor in Place



This 60,000-kw generator is the first unit of its size shipped by Westinghouse completely assembled with rotor in place. Built according to AIEE-American Society of Mechanical Engineers standards recently set up for the industry, the new construction makes possible shipping generators as single units saving time in loading, unloading, and assembly at the installation site. Only a single railroad car was required

Digests of Conference Papers of Great Lakes District Meeting

These are authors' digests of most of the conference papers presented at the AIEE Great Lakes District meeting, Des Moines, Iowa, April 1–3, 1948. The papers are not scheduled for publication in AIEE *PROCEEDINGS* or in AIEE *TRANSACTIONS*.

Synchrotrons; *Herbert C. Pollock (General Electric Company, Schenectady, N. Y.).*

For several years betatrons have been in use for the acceleration of electrons to energies as high as 100 million electron volts. In the betatron, the electrons circulate in a doughnut-shaped vacuum tube under the influence of a guiding magnetic field and are accelerated entirely by the changing magnetic flux within the orbit. In the synchrotron, higher electron energies are attained by the use of a radio-frequency electric field to impart acceleration to the electrons. A synchrotron is now in use at the General Electric Company for producing 80 million-electron-volt electrons and X rays of corresponding energy (see Figure 1).

An 8-ton magnet is driven at 60 cycles from an induction regulator. The magnetizing coils are resonated with a 3,000-kva capacitor bank. As the magnetic field begins to increase in each cycle, electrons are injected into the vacuum tube from an electron gun whose filament is pulsed negative for two to three microseconds with a voltage of the order of 50 kv. Following injection, acceleration is accomplished by betatron action for about 200 microseconds. At this time, when the electron energy is about two million electron volts, and the electron velocity 97 per cent that of light, a multivibrator circuit turns on a radio-frequency oscillator which excites a 163-megacycle cavity, forming a part of the vacuum envelope. The electrons become bunched in orbital distribution by the electric field at the gap of the resonator, and on successive revolutions they are held in synchronism with the radio-frequency field with a stability which is characteristic of the synchrotron. Following the turn-off of the cavity resonator, the electron energy will remain essentially fixed. If the magnetic guide field has not reached its peak, the electron beam contracts to strike a tungsten-wire target placed within the tube inside the synchrotron orbit. If the field has passed its peak when the resonator is turned off, the beam expands to hit the back of the injection gun and accordingly the X-ray beam comes from the gun.

When the magnet is fully excited, the peak value of the magnetic field at the orbit radius is 9,000 gauss, which permits a peak electron energy of 80 million electron volts. At present the X-ray yield in the center of the beam at one meter from the tungsten target is 500 roentgens per minute as measured by a Victoreen thimble in a one-eighth-inch thick lead shield.

As the electrons circulate in the vacuum envelope they emit visible light in the direction of their motion because of the high radial acceleration to which they continually are subjected. The electron beam has been photographed with high speed cameras and its motion can be followed readily during that portion of each cycle when the electron energy exceeds approximately 30 million electron volts.

Synchrotrons now are being constructed at Schenectady and elsewhere which will accelerate electrons to 300 million electron volt energies. A practical limit near one billion volts finally is set on the energy to which electrons may be accelerated by synchrotrons due to the increase of energy loss by radiation. The present application of the synchrotron is almost entirely as a research tool in the field of nuclear physics.

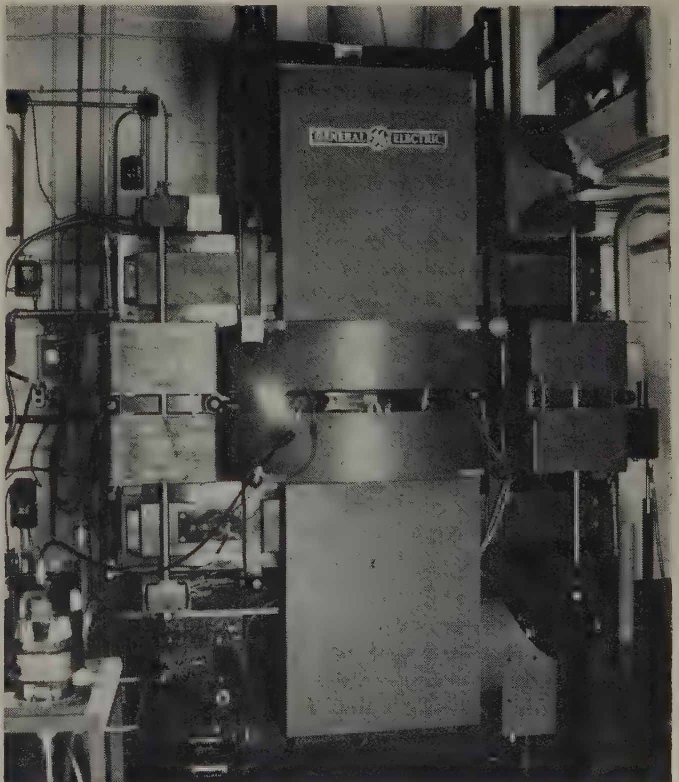


Figure 1. The 80 million electron volt synchrotron in use at the General Electric Company, Schenectady, N. Y.

The Fixed Frequency Cyclotron; *John J. Livingood (Collins Radio Company, Cedar Rapids, Iowa).*

The purpose of a cyclotron is to produce very energetic ions which may be used to transmute or render radioactive the atoms of the target on which they fall. For this purpose ions with energies equal to that attained in a free fall through many millions of volts are necessary. Such energies are obtained in a cyclotron by the repeated application of a relatively small accelerating voltage.

This voltage is produced between two hollow metallic electrodes acting as capacitors on the ends of foreshortened quarter wave length transmission lines in an evacuated enclosure, the system being driven by a radio-frequency oscillator. The hollow electrodes or "dees" are located in a strong magnetic field. Positive ions produced in an arc source at the center are accelerated into the interior of that dee which is negative at the moment and are curved into a circular orbit by the force due to the magnetic field. Upon arriving at the gap between the dees, the voltage is found to have reversed, resulting in a second acceleration into the second dee. It can be shown that the time to complete a circular orbit is independent of the orbit's radius, so that a fixed frequency oscillator may be used to keep the ions spiralling outward, gaining energy twice each revolution. The final kinetic energy is given by $H^2R^2e^2/2M$ ergs, where H is the field strength (gauss), R is the final radius (centimeters), e is the charge on the ion (electromagnetic units), and M is its mass (grams). The required frequency of the oscillator is $f=He/2\pi M$ cycles per second. Cyclotrons generally operate with H equal to about 15,000 gauss, and when accelerating deuterons (ions of heavy hydrogen) the frequency is in the neighborhood of 11 megacycles per second.

Two circumstances tend to prevent the successful operation of the ideal system outlined. First, to prevent loss of most of the ions in their flight of several hundred feet, magnetic focussing forces must be used, obtained by making the magnetic field decrease radially, a few per cent. Second, as the ions gain energy, their mass increases, because of relativity. The decrease in field and the increase in mass both conspire to make longer the time for an orbital revolution, so that the ions begin to slip in phase with respect to the oscillator frequency. If this continues too much, the ions will lose energy, rather than gain it, on crossing the gap between the dees.

If extremely high energies are desired (several hundred million electron volts), the oscillator frequency may be decreased as the ions spiral outward (frequency modulated cyclotron, or synchrocyclotron) at the expense of reduced number of particles per second. If intense currents of ions at moderate energy (20 million electron volts) are wanted, the fixed frequency cyclotron is adequate, provided that high dee-to-dee radio-frequency voltages are used (300,000 to 500,000 volts), for then the desired energy can be attained with comparatively few revolutions, before the ions can slip too far out of phase with the dee voltage. This requires a resonant dee structure of high *Q*; the necessary voltage then may be reached with a radio-frequency power of several hundred kilowatts.

Nuclear Reactors; *A. Wattenberg* (*Argonne National Laboratory, Chicago, Ill.*).

To understand the design problems and future possibilities of nuclear reactors, it is necessary to know what is meant by a nuclear reactor and the present state of development of these reactors.

A nuclear reactor is an assembly of uranium (or other fissionable elements) and some material which serves to slow the neutrons down, such as graphite. A slow neutron hitting a U^{235} nucleus (one of the isotopes of uranium) produces fission. The fission process is accompanied by the emission of several new neutrons. These initially fast neutrons are slowed down and at least one of them proceeds to hit another U^{235} nucleus and causes fission with the emission of more neutrons. In this manner we obtain a self-perpetuating nuclear chain reaction.

Accompanying the fission process is the production of large quantities of energy and nuclear radiations such as beta rays and gamma rays. Those neutrons which do not get used up in the fission process produce nuclear transformations or transmutations. One very useful transformation that occurs is that which converts U^{238} into plutonium. During the war the nuclear reactors were constructed mainly for the purpose of producing plutonium which was used in atomic bombs. At the present time other elements are being bombarded with neutrons in nuclear reactors to produce the radioactive isotopes that are being applied to peaceful purposes.

The first self-sustaining chain reaction was put into operation on December 2, 1942, in Chicago. Since then other reactors have been built at Oak Ridge; at the Argonne National Laboratory; at Hanford, Wash.; at Los Alamos, N. Mex.; at Chalk River, Canada; and at Harwell in Great Britain. It is known that units are being designed and constructed in the United States, Great Britain, France, and the Low Countries.

In the future we expect nuclear reactors probably will be useful in producing electric power, providing power for ocean vessels, producing heat in large specialized industrial installations, providing high temperatures for chemical industries, and for producing radio isotopes. Only the last of these possibilities has been realized up to the present. Research is being carried on towards the realization of these other possibilities. The problems that have to be solved arise from the fact that nuclear reactors can produce useful power only if they operate at high temperatures. Some of the present reactors already are turning out enormous quantities of power; however all of them operate at low temperatures so the power cannot be converted efficiently into useful forms.

A basic principle that generally is not grasped is that any nuclear reactor can be brought up to any desired power and temperature if the materials of which it is constructed can stand that temperature and if some method of removing the heat can be devised. The most obvious manifestation of this principle is in an atomic bomb. An atomic bomb is a nuclear reactor except that when it is allowed to rise to a temperature of millions of degrees it blows itself apart. The main problems of operating a reactor at a high temperature are the problems of finding materials that have the proper combinations of thermal and nuclear properties and the problems associated with the transfer of large quantities of heat from small volumes.

We find that many of the coolants and many of the structural materials that are commonly useful for constructing a heat transfer system cannot be used in nuclear reactors. One reason is that they have a high probability for absorbing slow neutrons and would stop the chain reaction when they were introduced into the reactor. We have been forced to study the properties of new coolants, to investigate the metallurgy of the less familiar metals, to investigate the fabrication and large scale manufacture of materials that previously have been only laboratory curiosities, and to design the special equipment that will withstand the intense nuclear radiations that are associated with these reactors.

These things have taken time and the problems only partially are solved. However, the Argonne National Laboratory is pretty far along in the designing of an experimental unit to produce useful power. It still may take two years before an experimental machine is in operation. It undoubtedly will take several years after that to construct a pilot plant and an industrially useful power producing unit.

We really are involved in a rather long range program, and for the next ten years nuclear reactors for power production will be curiosity items rather than common installations.

Radiation Measurements; *D. S. Martin* (*Iowa State College of Agriculture and Mechanic Arts, Ames, Iowa*).

The radioactive isotopes now available, used together with various radiation detectors which serve as instruments of quantitative analysis, have permitted the solution of chemical problems, such as identification of the several hundred known isotopes, as well as an understanding of many reaction mechanisms. In general, it is necessary to make accurate comparison of radiation intensities; fortunately, absolute values seldom are required. The selection of an instrument must be determined partially by the radiation in question, although dependability and simplicity frequently must be considered by workers without extensive electronics experience. Most (but not all) methods make use of the ionization of gas molecules by the radiation and employ an electrical field to collect the ions. Relatively cheap quartz fiber electroscopes have been used widely for measuring these ion currents. However, the difficulties of d-c amplification have limited the popularity of electronic electrometer circuits.

Greatest sensitivity in radiation detection has been achieved by circuits which count the pulses of ion current occurring with ionizing events; in general, pulse amplifiers and recording mechanisms are required.

For heavy particles producing 10^5 ions and with a range of a few centimeters in gas the ions can be collected with low fields to give 0.1 millivolt pulses. Sharper pulses and greater freedom from microphonics result when R-C time constants of 1–5 microseconds are used giving only the electron collection pulse. Pulse magnitudes depend upon the potential "fall" for the electron in the chamber. With good amplifiers, pulses ten times the "hash" can be counted at rates in excess of 10^5 per minute for heavy particles.

Electrons and electromagnetic radiations yielding much lower ion densities and correspondingly greater ranges require some sort of tube counter employing cylindrical symmetry. Higher fields in the vicinity of a central wire permit additional ionization by accelerated electrons, thus yielding "gas amplification." Because of the motion of ions in a $1/r$ field, the pulses rise to half their values in a few microseconds, although as much as 500 microseconds are required for collection. With moderate ratios of field to pressure, gas amplification is proportional to the initial ionization. In such instances, pulses resulting from light and heavy particles can be distinguished.

With higher electric field to pressure ratios, ionization continues until the space charge reduces the field sufficiently to quench the discharge. Such a counter, a Geiger-Mueller tube, is therefore insensitive for a few hundred microseconds following each pulse. Essentially, the same pulse results from 1 ion pair or 10^6 ion pairs. A critical requirement is the prevention of subsequent spurious pulses triggered by free elections formed when the ions reach the cathode. Such pulses generally are prevented by electronic control of the applied voltages or by adding a heavy organic vapor to the commonly used argon gas. Electronic amplification is a minimum, counting rates of 10^4 per minute are practical, a background of 10–40 counts per minute from cosmic rays and stray radiation affords a limit to the sensitivity.

Geiger-Mueller tubes, which can be modified suitably for use with any radiation, have been used widely. The quality of the instrument is indicated by the voltage range for a flat response. The construction of good Geiger-Mueller counters has been possible with only a low probability and the units accordingly have been necessarily expensive. Their preparation is still largely a matter of "art" and superstitions. Some precautions whose necessity in some instances has been proved with dubious certainty, include: vacuum-tight envelopes, cleanliness from dust, long pumping at high vacuum, exceedingly pure filling gases, and special treatment of metal surfaces.

Almost essential for radiochemical studies is a small counter with a very thin mica window to permit entry of soft radiation. The accuracy of analyses may be better than five per cent depending largely on reproducibility of sample mounting.

Digests of Papers Presented at Conference on Electron Tubes

These are author's digests of most of the papers presented at the AIEE conference on electron tubes for instrumentation and industrial use which was held in Philadelphia, Pa., March 29–30, 1948.

Full texts of all the papers and discussions are being published in the "Proceedings of the Conference on Electron Tubes" which will be available soon at $3 ($1.50 to AIEE members).

The "Report on Electron Tube Survey" prepared by the AIEE joint subcommittee on electronic instruments, contains data on which much of the information discussed at the conference was based. It is available at $2 per copy ($1 to AIEE members).

A special price of $4 ($2 to AIEE members) is being offered to those ordering both publications at the same time. These orders should be sent to AIEE Order Department, 33 West 39th Street, New York 18, N. Y.

Objectives of Conference

W. R. Clark (*conference chairman; Leeds and Northrup Company, Philadelphia, Pa.*). The application of the electron tube in instrumentation and for other industrial uses is still in its infancy. Its future is tremendous. One serious obstacle in the way of rapid progress is the unreliability of tubes and the unreproducibility of characteristics from tube to tube.

In an electronic circuit no other single unit has as high a performance to cost ratio as the electron tube. It is an invaluable versatile inexpensive performer.

Up to the present time however, manufacturing emphasis has been placed on reducing the cost of the tube without seriously impairing its performance. What must be done to fulfill the requirements of industry is to shift the emphasis from reducing costs to improving performance. If the tube manufacutrers will do this and produce better tubes, keeping the same ratio of performance to cost that now exists, they will have made a tremendous contribution to industrial electronics.

This conference has been planned as an educational program for both the industrial tube users and the tube manufacturers so that both groups would have a better understanding of each other's problems.

Five different sessions were arranged.

Session 1 gave appraisal of the needs for electron tubes with special characteristics for use in instrumentation and industrial applications in terms of the functional requirements of these tubes with particular reference being given to the inadequacies of conventional types of tubes. The results of the survey conducted by The Scientific Apparatus Makers of America were presented and discussed in general terms. This survey is of interest to us because the electron tube problems of this usary group are very similar and duplicate to some extent the electron tube problems of the groups covered by the survey conducted by the AIEE joint subcommittee. The last part of the first session was devoted to a detailed discussion of the survey conducted by the AIEE joint subcommittee and the tabulated results were presented and discussed.

In session 2 the function and aims of the Joint Electron Tube Engineering Council were presented, and current development programs for obtaining improved tubes for use by other special user groups were discussed to determine the possible bearing of these programs upon each other and upon instrumentation needs.

As part of the dinner program the manufacturers policy with relation to all special tubes was the theme of Doctor Baker's talk. This talk was the keynote for the subjects discussed at session 3 immediately following the dinner. At this session, design, manufacturing, and economic considerations on the part of the electron tube manufacturers were presented. This gave the tube users an insight to the various problems confronting the manufacturers in making special tubes.

Sessions 4 and 5 on Tuesday, were devoted to an open discussion on specific tube types which are in greatest demand as determined by the survey. Hypothetical tubes having electrical and mechanical characteristics based on these requirements given in the survey results which can conceivably be obtained with reasonable costs were presented and in each instance the specific tube and its proposed characteristics were discussed from the point of view of the user as well as the manufacturer. These two sessions were arranged to serve as a check on the committee's interpretation of the results of the survey. If there are any characteristics of a particular tube which are not in accordance with the general overall needs of those present at the conference, the committee would like to have these discrepancies brought to light and the characteristics of the hypothetical tube, if warranted, will be modified accordingly.

It is hoped that as a result of this conference, this subcommittee will be able to formulate clear and precise information on various types of tubes for use in instruments and for industrial use, which will be a guide to the tube manufacturers in initiating a program for manufacturing a line of tubes that will meet the demands of a large majority of users in this special field. It is also the committees wish that some of the requirements of other special users groups can be incorporated into these new tubes to keep the number of various types of special tubes at a minimum and to have interchangeability between various users groups.

The proceedings of this conference will be published along with the recommendations of the AIEE joint subcommittee on electronic instruments based on the results of the survey and the discussions of this conference.

Need for Improved Quality in Electron Tubes for Instumentation and Industrial Uses

W. C. White (*General Electric Company, Schenectady, N. Y.*). Differences in viewpoint between the users of tubes and tube manufacturers are just as natural and fundamental as the rivalry between pedestrians and drivers of automobiles. In both instances, each believes the other could easily quite change his ways and, if he only would, there would be benefit to both parties and certainly to himself. The analogy might be carried still further. When occasionally a tube user becomes a tube maker, the change in viewpoint is just as wonderful to behold as when the pedestrian steps into his car and drives away.

The story of progress in almost every field contains the familiar cycle of specialization. Edison launched the utility industry with two or three types of incandescent lamps. Now types of lamps are probably in the thousands, highly specialized for each application. We even try to improve on nature and breed dogs from such extremes as drawing sledges to looking pretty on a lady's lap.

The author took an active part in the development and design of the first line of radio receiving tubes used in commercial broadcasting. These were developed and put on the market early in 1921 which was just as soon as possible after the patent situation was cleared up and the Radio Corporation was formed in October 1919. At that time we thought that two types certainly would meet the need, one of these to operate from storage batteries and the other from dry cells. Maybe that was not good engineering, but it was certainly good business. The tube business was profitable and we actually got away with just two general types of tubes for about three years. Really the first break from this highly simplified, and from the tube makers' desirable, situation was in 1924 when it was found that a special tube for the audio output stage gave greatly improved quality. That was the beginning. From then on specialization grew rapidly. There was a real need then for that one special tube. Now there is a real need for increased specialization.

There is another factor which must be taken into account. Since 1939 the increase in the total number of receiving tubes made per year has gone up, of course, but actually less than twofold. However, the use of small tubes in industry and other noncommunication applications, I venture to guess has gone up nearly a thousandfold. I believe that just one modern device, such as ENIAC, probably uses nearly as many tubes as all industry did 15 years ago. I again believe this latter factor alone more than justifies a conference of this sort.

Of course, there have been countless discussions by small groups on this problem and in the past, as I have indicated, it was a small problem. No longer, however, is the subject a small problem. It has become a big problem both in quantity and scope and, therefore, we cannot hope to obtain the solution by a meeting of only a few minds. Big problems require bold, large-scale attack and this conference is such a move and can be expected to yield results.

C. T. Burke (*General Radio Company, Cambridge, Mass.*). The manufacture of measuring and testing as contrasted to control equipment requires uniformity and dependability in vacuum tube characteristics.

As instrument manufacture does not present the mass market required for economical electron tube manufacture,it has been forced to rely for its basic component on devices designed for the requirements of another industry. The industry now has reached the where it seems that a modest mass production of tubes designed for its requirements could be supported.

The fundamental requirement is uniformity so that designs can be frozen on the basis of vacuum tube equipment without subsequent delays or redesigns being required by the failure of later tubes to reproduce the behavior of the earlier type.

The actual values of parameter are less important than their uniformity and permanence.

Tube selection is unsatisfactory to the vacuum tube manufacturer, to the instrument manufacturer and to the ultimate user.

Availability of tubes for replacement is important as instruments in intermittent service have a long life.

Cost of electronic tube equipment is a minor part of the instrument cost as a rule and can be increased materially in return for improved performance.

An increased life span would make the greatest single contribution to the solution of our problems. A 10,000-hour life (under intermittent service) would be equivalent to immortality in most of our applications.

Uniformity in addition to life is required to reduce the laboratory time needed for the selection and calibration of original electron tube equipment.

It is hoped that this contact between instrument and electron tube manufacturers will continue as it offers a meting ground where requirements, possibilities, and probable markets for specialized types of electronic tube may be correlated.

A. P. Upton, (*Minneapolis-Honeywell Regulator Company, Minneapolis, Minn.*). These comments are limited to experiences with major aeronautical electonic applications that is, turbo supercharger control, automatic pilot, and electronic fuel gauge, during the war; and new tube developments for the same postwar applications.

The equipment mentioned was used on 35,000 bombers in all parts of the world. Some one million tubes involved, exclusive of spares. While attempting to get tube manufacturers interested in higher quality tubes for war and postwar use, current tubes had to be chosen because of the time element. Loctals were chosen chiefly because of their ability to operate at altitude without arcover. Experience showed arcover in octals between leads coming from the press, and across bases between pins.

As a means of improving the score in the field, turbo supercharger amplifier tubes, for example, were purchased and checked on the following procedure:

1. Purchased JAN inspected-at-source.
2. One hundred per cent retest by our inspection.
3. A 100 per cent runin of amplifiers under 170 degrees Fahrenheit ambient temperature, operating turbo waste gate motors in both directions with idle cool-off time between. Object—to catch leakers and other possible faulty tube construction.
4. Standby for 48 hours to allow leakages, if any, developed during runin period to show up before shipment.
5. Retest of amplifier performance before packaging. This performance, as well as field performance tests, were made under operating conditions rather than in a tube tester. Known signals delivered minimum tolerable voltages across output loads as criteria of quality of voltage amplifiers, power tubes, and rectifiers.

Factory score sheets showed greatest troubles were: short circuits 50 per cent, broken beads 20 per cent, low emission 18 per cent. Balance of rejects caused largely by bent pins and stems, loose bases, cracked envelopes, and so forth. Because of this close inspection, unscheduled field replacements were under one-fourth of one per cent. (Unscheduled means tube removed before regular replacement periods because of unanticipated faults.)

In contacting tube manufacturers, the need for both electrical changes and mechanical improvements was emphasized. Electrical changes needed because most tubes available were designed for communications and not for control purposes. Need for mechanical improvement born out by factory score. This means new tubes were needed not doctored old ones.

The beginning was slow but now we have tubes expected to give 5,000 hours of service. These are not the ultimate, but they are improvements. These tubes include such design features as

1. Because of the generally satisfactory mounting and adequate spacing within the loctal types, the button construction was followed with sufficiently long leads to be used in an octal base.
2. For higher voltage applications, we make our own octal bases with barriers inside and out to reduce arcover possibilities. Material is melamine, because of its char-resistant properties, of value should arcover occur.
3. Power type has radiating fins on the plates for better heat dissipation. Both voltage amplifier and power type have gold-plated grids for reduction of contamination and better heat conduction.
4. A second mica disk below the elements assembly adds rigidity.
5. The upper mica disk is spring-loaded against the tube envelope, and strips spotted to the supports are folded over the mica to prevent sawing in mica. The voltage amplifier is a twin triode with a mu of 100, number *2C52*.
6. Twin triode power type is a *2C50* with a plate dissipation of about four watts per plate, of low impedance (4,000 to 5,000 ohms) simplifying load matching. The melamine base is used on this tube.
7. These are both given 200 hours of burn-in by the manufacturer before shipping. The rectifier is a *1274*, a *7Y4* in our melamine base.
8. A larger twin triode, the *3C33*, is rated at 15 watts plate dissipation per plate. Made in a 829 envelope. Impedance 1,500 ohms thus simplifying load matching.

As indicated before, these are gains, but we do not have the ultimate. This is a start but a long way from the final. A final appeal to tube manufacturers to design tubes for control purposes meeting these unusual requirements rather than revamping existing receiving types.

Harry F. Dart (*Westinghouse Electric Corporation, Bloomfield, N. J.*). From timid beginnings electron tubes have earned an essential place in industry which has increased by a phenomenal amount during the past decade. With ever-increasing uses any list of applications soon becomes obsolete. Jobs range from controls, power sources, and welding, to a variety of measurement and inspection devices.

There is a decided need for improvement in the quality and uniformity of characteristics of electron tubes for use in industrial equipment which for this conference has been limited to the general types corresponding with the receiving tube sizes. Naturally there are many points of similarity and some which rate very differently on importance when these requirements are compared with the survey made by the instrument manufacturers.

The main improvements in electron tube characteristics desired by the industrial equipment manufacturers may be summarized as (and not necessarily in the order of relative importance); desire long reliable life of 10,000 hours, need published range of limits on characteristics, want less hum and much less microphonics when subjected to severe shock and vibration (5 to 10 times gravity), need greater uniformity of plate current and mutual conductance both between individual tubes and with life, characteristics should be stabilized and not subject to arbitary changes, need a test to predict the imminence of failure, type life or stock availability should be 15 to 20 years, and shelf life characteristic must be good.

The industrial equipment designers do everything they can in circuit design to make the tube a true control device and to get stable tube operation. Some of these features include; the use of inverse feed-back amplifiers, the utilization of push-pull and parallel amplifier circuits to average out tube differences, the addition of an extra coupling or buffer stage, the utilization of standard basic types of tubes, the addition of series resistors both to stabilize and protect the tube, the provision of adequate control voltage or driving power for stable operation, and the elimination of inductive pickup and power supply ripple by circuit design and layout.

There does not appear to be such a large difference in potential demand for industrial tube use if the price is ten, five, or two dollars as is indicated for the instrument manufacturers. Some information is included and presented as recommendations as to how best tube life is being obtained. While it is probable that many designers will include the specially designed tubes in their product, most importance will attach to the actual practice of the equipment users and their insistence, or lack of it, as to how extensively any of the special tubes are used as replacements.

F. B. Bramhall (*Western Union Company, New York, N. Y.*). The Western Union Telegraph Company currently has in service in its various types of thermionic equipment approximately 150,000 vacuum tubes, and the number is growing rapidly. The company therefore has expressed considerable interest in the moves to establish a classfication of "industrial" type of tube to be characterized by one or more of the properties of longer life, and greater ruggedness and reliability.

While many classifications of tubes are used, certain broad requirements dominate their selection. The primary telegraphic receiving instrument is an electrically-operated typewriter requiring 70 milliamperes of current operating into a 1,000-ohm load with, in general, a 110-volt source of anode current. These conditions specify the character of power output tube desired for terminal distribution service. A second dominant requirement is integrity of performance, and this is reflected principally in two ways. The electro-mechanical telegraph printer exercises no intelligence to supply a missing or incorrect message detail in conformity with context, or to ask for a repeat—every pulse must be free of distortion within specified limits, or a wrong letter will be printed. Secondly, circuits on trunk routes carry a multiplicity of messages simultaneously, ranging from a few dozen on a carrier telegraph circuit operating on a pair of wires to 1,000 or more on a microwave radio circuit. With perhaps hundreds of tubes involved in the circuit,a failure or aberration in a single tube will cause errors in a large number of messages. Quality and longevity of tubes also reduce the burden on preventive maintenance here.

As the tubes are in operation 24 hours daily, power consumption is an important factor. This consideration at present is directing a trend toward the use of 25-volt a-c heater supply.

For the more commonly used types of receiving tubes, 10,000 hours of continuous service can be expected. In some classes of service, a substantial premium could be offered for a line of tubes which would have several times this life expectancy. In other classes, only pro rata price premiums would be justified.

Survey Conducted by the Scientific Apparatus Makers of America

J. W. Harsch (*Leeds and Northrup Company, Philadelphia, Pa.*). In the early spring of 1946 several member companies of the recorder-controller section of the Scientific Apparatus Makers of America had indicated trouble in the continuity of supply and in some instances obsolescence and unavailability of tubes which had been designed into production instruments. This indicated that the instrument manufacturers in all probability were facing a definite problem in the continuity of supply of not only electron tubes but other electronic components. It long has been the practice in the instrument industry to maintain repair parts and repair service for long periods of time after an instrument design has been replaced or become obsolete. This, in general, ranges from 15 to 30 years. It is fairly common practice to think of life of instrumentation as of the order of 25 years.

The unavailability of tubes seemed a problem of sufficient importance that a decision was made to make a survey of the use of electron tubes in instrumentation, with the thought that from the results of this survey we might contact manufacturers of electronic components and reach some understanding as to the length of time we might expect these components to remain available and also at the same time to check on factors affecting continuity of supply. We also had discussed the needs for somewhat higher grades of components to accomplish increased dependability of our instrumentation.

Our survey covers replies from 8 of the 10 companies in our group who are interested in electronic components. The following are the questions which were asked of the participating companies. (Space limitations do not permit the inclusion of the replies but a summary of the answers may be found in the "Proceedings" of the present conference on electron tubes.)

Question 1. List the electronic tube types which you now use, the approximate number of each which you require, and the types most critical with respect to circuit application.

Question 2. List the types not shown under question 1 which you will use in new designs and check if special characteristics or tests will be required.

Question 3. What changes or improvements would be most desirable in the various tubes?

Question 4. Class of tubes you prefer (from standpoint of construction).

Question 5. When separate base is used, what material do you prefer?

Question 6. Indicate the points concerning basing which you consider critical.

Question 7. Indicate electrical test items or characteristics most critical in your application.

Question 8. Indicate most common causes of failure.

Question 9. What unusual conditions external to the tube contributed to your highest per cent of failures?

This work at the present time is inactive in our group, largely for two reasons. The first is that our immediate supply problem corrected itself to a considerable extent during the time required for the survey and, secondly and more important, the AIEE subcommittee on electronic instruments started a survey which was broader in scope and indications were that from that work would come the answer to our problem.

To the SAMA the important aspects are

1. Continuity of supply.
2. Period of availability after notice of withdrawal from market.
3. Tubes and other components of improved quality and greater dependability.

Survey Conducted by AIEE Joint Subcommittee on Electronic Instruments

FORMULATION AND CIRCULATION OF QUESTIONNAIRE

H. R. Meahl (*General Electric Company, Schenectady, N. Y.*). The AIEE joint subcommittee on electronic instruments realized that to obtain specific data on all tubes required by the instrument industry would result in a questionnaire that would be too complicated to encourage many returns. However, sufficient data on tube characteristics had to be obtained to make the results of the questionnaire valuable to tube manufacturers. A questionnaire finally was drawn up that asked for data on required tube life, choice of characteristics (with their tolerances) that should be most nearly constant during life or from tube to tube, features believed to be most urgently in need of improvement, unusual operating conditions, type of ultimate application, preferred envelope, numerical demand per year, and quantities likely to be stocked.

To guide thinking, ten standard tube types were proposed as prototypes on which to base comparisons in formulating requirements for improvement. They were

6H6 (twin diode), *6SN7GT* (medium-mu twin triode), *6SL7GT* (high-mu twin triode), *6SJ7* (triple-grid detector-amplifier), *6SA7* (pentigrad converter), *6L6* (beam power amplifier), *6A3* (power amplifier triode), *6X5* (full-wave high-vacuum rectifier), *VR150* or the *OD3* (voltage regulator), and the *RH507* (electrometer tube).

A mailing list was compiled with the aid of information obtained from AIEE headquarters and from various other professional societies and technical magazines. About 900 questionnaires were distributed early in 1947. Follow-up letters were sent to all from whom replies were not received within a reasonable time. Although the questionnaire at first may have appeared unduly complex, a good response was obtained and yielded a great amount of valuable information.

METHOD OF SUMMARIZING REPLIES

E. J. Isbister (*Sperry Gyroscope Company, Garden City, N. Y.*). The analysis of the replies to the vacuum tube questionnaire sent by the AIEE joint subcommittee on electronic instruments was conducted generally as follows: The data were divided into two groups; that reported by institutions having a demand at $2 per tube in excess of 1,000 tubes per year, and that reported by institutions having a demand of less than 1,000 tubes per year.

After tabulation, the various numerical characteristics were averaged. In general, the average was weighed by the demand for tubes at $2 per tube.

After averaging, the results were reduced to a common basis of 100 and labelled the importance rating figure. This is the figure shown in parenthesis with each characteristic in the final tabulation of results.

Special requests and other comments were referred to another group for analysis.

RESULTS OF QUESTIONNAIRE—A GENERAL SUMMARY

T. B. Perkins (*Radio Corporation of America, Harrison, N. J.*). The results of the survey of the Electronic Industry by the AIEE Joint Subcommittee on electronic instruments showed enough consistency in their requirements specified for the ten types of tubes summarized to warrant some general conclusions. It is definitely indicated that electron tubes giving a minimum of 10,000 hours life are wanted.

The importance listing of the characteristics desired for the ten types allow some generalizations. Plate current occupied an important position for rectifiers, double triodes and power tubes. Mutual conductance had high rank in the sharp cut-off pentode, power tubes and convertor. Balance had real importance in all double tubes. Amplification factor was high in importance in the high-mu twin triode, sharp cut-off pentode and multigrid convertor. Grid cut-off voltage was especially significant in the double triodes, the power tubes and the electrometer tube. Grid current was of prime importance in the electrometer tube and of significance in the sharp cut-off pentode and power tetrode.

Tolerances of about plus or minus ten per cent in the tubes' important characteristics with life and between individual tubes were desired. Hum was the item stated as needing the most improvement, microphonics next and noise level last. The order of importance given the unusual service operating conditions were: excessive vibration, high temperature, high humidity, excessive shock, low pressure, excessive dirt, low temperature and exposure to chemicals. The preferred type of envelope was generally the miniature. The type of usage for these special tubes was found to follow this order: government, light industrial, consumer, heavy industrial and laboratory.

The order of demand at $2 per tube, in terms of the prototypes, were: *6SN7GT*, *6SJ7*, *6SL7GT*, *6H6*, *6L6G*, *OD3*, *6X5GT*, *6SA7*, *6A3*, and *RH507*. The demand for the twin triode low mu tube was approximately 340,000 per year at $2; 57,000 at $5; and 27,000 at $10 per tube. The average ratio between demand at $2 and that at $5 was approximately five to one, while the ratio between \$5 and \$10 was approximately two to one.

RESULTS OF QUESTIONNAIRE—UNUSUAL REQUESTS

G. N. Mahaffey (*Sylvania Electric Products, Inc., Williamsport, Pa.*). In reviewing the questionnaries of the AIEE joint subcommittee on electronic instruments, it was observed the survey shows a need for vacuum tubes having unusual characteristics and for other tubes in addition to those covered by the ten most commonly used types in keeping with the advancement of the industrial and instrumentation fields. Approximately 100 questionnaires, which were supplemented by comments and letters, were reviewed. Only specific remarks were considered and statements which did not seem entirely reasonable in the absence of clarifying data or which did not fit readily into the pattern of other manufacturers were not reported. In general, comments were very much to the point and included reduction of physical size; more rugged construction to meet wider extremes of usage; further reduction of noise level tolerances; increased heater cathode voltage rating on regulator voltage amplifier tubes; greater uniformity, stability, and balance of contact potential in the twin diode; lower leakage between grid and other elements for the *6SN7GT*, *6SL7GT*, and *6SJ7* tubes as well as for the electrometer tube; reduced heater power for these type tubes: *6SN7GT*, *6SL7GT*, and *6SJ7* and a dual heater rating has been requested, such as that used by the *12AX7* tube; need for better voltage regulator tubes and requests for redesigned beam power tubes to be used with higher grid resistances for fixed bias applications.

Some interest was shown in improvements in tubes other than the ten on which results were tabulated; however, the estimated demand was small and results were not summarized. Listed in order of their demand were the *2050* Thyratron, the *6SK7* triple-grid supercontrol amplifier, the *6J7* triple-grid detector amplifier (with grid out top of tube envelope), the *6AS6* miniature radio-frequency Amplifier Pentode (with suppressor grid terminal), the *5R4GY* full-wave high-vacuum regulator, the electronic indicator tube, photoelectric tubes, and various types of filamentary tubes.

The Functions and Aims of the Joint Electron Tube Engineering Council

Virgil M. Graham (*Sylvania Electric Products, Inc., Williamsport, Pa.*). Toward the end of the war it became evident that the engineering activities of the two trade organizations, the Radio Manufacturers Association and the National Electrical Manufacturers Association, were overlapping in the field of electron tubes.

In the fall of 1944 Doctor W. R. G. Baker, director of the RMA engineering department, along with A. C. Streamer then president of NEMA, took the initiative in organizing a joint group to handle the standards formulation work in the electron tube field for both associations.

This group was established as the "Joint Electron Tube Engineering Council" or "JETEC." The organization of JETEC was conceived as a tripartite arrangement comprising

1. Two directors, initially W. R. G. Baker and A. C. Streamer, for policy guidance, general supervision, and liaison with the parent associations.
2. A council of four—subsequently was increased to six, under the chairmanship of O. W. Pike.
3. A staff consisting of the chairmen of the 11 standing committees.

The line and staff standing committees of JETEC formulate material proposed for standardization or inclusion in JETEC data. Such material is subject to approval of the council after it has had 30 days consideration. When the council approves of proposed standards material it is recommended to the parent associations and may be put through their standardization procedures. If and when both associations approve it as standard, the material is published as a joint RMA-NEMA standard.

As they differ so greatly, a word about the standardization procedures of the two associations may be of interest.

In RMA all standardization work is carried on by the engineering department. Material proposed for standardization, of which that originating in JETEC is but a part, is submitted to the industry in the form of standards proposals. These are given the widest possible distribution to attract comment or criticism from any one having interest in the subject matter. These proposals do not, however, provide for a ballot or vote, but they do serve as a means of determining the sentiment of the industry without any attempt at quantitative evaluation.

Comments so collected are recorded centrally and then submitted to the chairman of the originating committee to give an opportunity for the elinination of any misunderstanding or misinterpretation on which objection might be based. When no further elimination of differences is possible and all responses appear to have been received, the proposal with a complete dossier of its history is referred to the RMA general standards committee.

The function of the general standards committee is to act in a purely judicial capacity deciding whether any remaining objections are valid. Its judgment determines acceptance or rejection of proposed standardization material.

The NEMA standardization procedure requires the reference of the proposed material to such of the sections of that organization as are concerned with the subject. After member companies of these sections ballot on the proposal it goes to the codes and standards committee for final approval if the balloting has been favorable.

The JETEC data, mentioned previously, are comprised of two general classifications, "tube" data and "component" data. The former consists of tube data sheets for individual types giving characteristics as developed by the appropriate line committee of JETEC with the approval by the council after 30 days consideration. The data sheet for each such type is printed for inclusion in the 400 copies of JETEC data books distributed in the radio and electron tube industry. These data sheets are the direct successors to the "white sheets" of tube data which were issued by the RMA Data Bureau before the war, after agreement by the appropriate committee and after circulation to the industry as tentative characteristics on the so-called "pink sheets."

For many years it has been recognized generally that, while the characteristics of tubes in common use wisely could be standardized, the processing of each type through the regular standardization routines would be impracticable.

Accordingly, the data defining a given type when it is initially registered with the Data Bureau stand in lieu of standards and remains valid as such until subsequent reregistration with the consent of the industry or until the appropriate JETEC committee formulates the JETEC data sheet and it regularly is approved by the council.

The "component" data are comprised of information presumably useful to the tube manufacturers but which are not crystallized to a point where standardization is in order. Data on moulded glass flares are a typical example. These JETEC component data may be formulated in any of the committees and is subject to the usual "30-day approval" by the council, after which publication is in order.

Current Programs of Electron Tube Developments

COMMERCIAL AVIATION

C. R. Banks (*Aeronautical Radio, Inc., Washington, D. C.*). Aeronautical Radio, Inc., is a nonprofit company owned by the air lines and staffed by air line engineers. Thus, its electron tube program; that is, that of procuring reliable electron tubes for air-borne service; is sponsored by the air line industry.

The importance of radio navigational aids to the commercial pilot is so great that air-borne electronic equipment is carried in duplicate to avoid the hazards of its failure. Such failure very often is the result of electron tubes which develop open filaments, short-circuited elements, intermittently short-circuited elements, or low emission.

Air line operations flight plans, and aircraft piloting have become more dependent on radio as the reliability of the equipment and service has increased. Today, air-borne radio is a facility of primary importance to the air line industry.

Analysis of air-borne electronic equipment failures proved the fact that electron tubes were contributing heavily to the unreliability of such electronic apparatus.

Therefore, in August 1946, Aeronautical Radio instigated a program to improve this situation. After many meetings with the manufacturers, it was found possible to interest two manufacturers in the production of some electron tubes to Aeronautical Radio's specifications. Many air lines supplied the manufacturers with continuous recording of aircraft operating voltages, actual hours of operation, and the on-off cycling of the equipment. The tube manufacturers' engineering engineering analysis of tube designs and service conditions were used to formulate improvements in the design, manufacturing, and testing of electron tubes. This type of testing, to obtain failure information, has proved, and will prove, invaluable in the furthering of the electron tube program.

A committee composed of representative air line communication engineers considered the many problems which arose; namely, the magnitude of the electron tube engineering involved in the program, the obsolescence of many tube types now in service, the wide service condition of the voltages encountered in aircraft, vibration, and the test of an electron tube to determine its suitability for service in air-borne equipment.

The aircraft radio equipment committee recommended a two-fold reliable tube program; namely, an interim program and a long-range one. The interim program was to establish methods of tube selection. As for the long-range program, Aeronautical Radio was to co-operate with the military, the Bureau of Standards, the railroads, and other groups interested in a long-life ruggedized electron tube program.

Too much cannot be said concerning the co-operation afforded the efforts of the air line industry by the tube manufacturers. It is recognized clearly that an electron tube cannot be improved in quality or reliability by testing. Quality must be built into the tube. By providing production and shrinkage data, and by conducting life tests under conditions simulating aircraft service, the electron tube manufacturers are aiding materially in furthering the over-all program.

DIGITAL COMPUTERS

R. L. Snyder (*University of Pennsylvania, Philadelphia, Pa.*). Large-scale electronic computers, particularly the numerical types, employ thousands of vacuum tubes. It is essential that they function perfectly when the equipment is operating. There are two different attacks to be made on the problem of reducing interuptions resulting from tube failure. The first is the manufacture of improved types of conventional tubes which are characterized by reliability and long life. The second is the development of special types of tubes, each designed to perform operations which now require a number of conventional tubes, thereby reducing the over-all equipment and consequently the rate of failure. Obviously, a combination of both techniques is indicated.

In the former category it is recommended that greater heater cathode insulation be provided and that more ductile heater wire be used; also that the miniature base pins be enlarged at the press and a little beyond to increase their strength and to permit greater dissipation.

Special or unconventional tubes needed for computer construction and for other purposes include low-voltage triodes and pentodes having continuous plate current ratings in the ranges of 0.3, 1, 3, and 10 amperes. The cathodes of such tubes must be quite large and therefore can be equipped with 110-volt heaters. These tubes are needed to provide simple high current regulated d-c supplies and low impedance signal sources. Another innovation is suggested in which an electrically deflected low-voltage high-current ribbon-shaped cathode-ray beam is directed at a plurality of targets which constitute the output electrodes. This tube provides means for simple switching operations and, most important, permits direct coupling between tubes because the output electrodes can operate at the same d-c level as the control electrodes.

NAVY

J. W. Greer (*Bureau of Ships, Washington, D. C.*). The Navy would welcome improved specifications for electron tubes, particularly for long life and dependability. Characteristics requiring better specifications are noise, pulse ratings, cutoff, high-frequency performance, including admittances. Methods of testing these established ratings may assure better performance during life for such items as grid emission.

About 1,600 types presently are stocked by the Navy. During 1944 about 130 million receiving tubes were produced. In any future war production may be greater, but the number of types should be reduced through use of the Army-Navy preferred list. During peacetime service procurement represents small percentage of industry output.

Improved tube quality required good electrical and mechanical design, production experience, and aging; other methods not practical. The ruggedized program calls for design of reliable, high performance tubes, whose operation is not impaired during transportation, shock, vibration, and possible overloads.

Production experience on high quality tubes can be accomplished best if all users join and order tubes according to one specification for each type. Most receiving tubes now only serve minimum requirements of commercial radio. Recently interest has been evidenced in improved types for industry, television, and high quality instruments. Demand from these programs separately is insufficient to support production. A compromise to a single line of high quality tubes would do much to assure continuous production.

Ruggedizing is necessary for wartime transportation and equipment operated under shock conditions. Approximately 30 receiving types, including nine miniatures, are being ruggedized under Navy contracts.

Life will be improved by production experience and by incorporating processes resulting from research on cathodes. If sufficient ruggedized tubes are not available in wartime, commercial counterparts could be used for military purposes.

Use of uncontrolled characteristics, for which specification limits cannot be established, or of tolerances closer than can be met in regular production, is not acceptable in military equipment design, particularly if use of regular tubes would cause equipment failure. Characteristics for which selections are made may become numerous and involved. Their control may not be known to manufacturers, so that supplies meeting selected characteristics cannot be assured. Any system based on selection of characteristics would be difficult to administer and would mean that certain sections of quality would be selected for particular orders, and other tubes would not show normal production variations and may be well below standard.

In conclusion, it is emphasized that the use of ruggedized tubes, with sufficient orders for continued production, will fill needs for long life, dependable operation, and resistance to shock and vibration, both in service and in handling. Use of designs not incorporating the ruggedized features would mean production of tubes which are not adequate in an important requirement for highly expensive equipment on which national security may depend. Once a tube has been designed with ruggedized features, the tube cost would not be increased materially, over an "instrument" tube, and even may be lowered if additional orders are obtained, such as Navy procurements.

ARMY

John E. Gorham (*Signal Corps Engineering Laboratories, Belmar, N. J.*). Hope is expressed for the furtherance of greater understanding between the tube industry, the electronic equipment users of tubes, and the services so that in the event of another war there will be a minimum of peacetime-to-wartime production transition difficulties. The Army-Navy Preferred List of tubes has somewhat less than one-tenth of the 5,000 types of tubes presently known, and all new service equipments are required to use only tubes on that list. The advantages of joint service procurement and interchangeability between services in the field are obvious and, in general, it is with great difficulty and reluctance that services grant waivers from this list. The reason why, on one hand, tube types in service equipments are limited severely, and, on the other hand, many new tube types are sponsored, is explained by the fact that these new developments represent solid advances in the art of tube design. It is hoped that the tubes which this meeting indirectly causes to be developed will represent solid fundamental improvements over the present art and will be agreed to for the whole industry by JETEC and for the services by JANETC, and will not be special selections so easy when the quantity is small and so troublesome as the demand grows.

Consolidation of the air line-railroad-industrial line of tubes, where long life and electrical and mechanical dependability are principally important, with the line of service ruggedized tubes and the proposed instrument and industrial line would have many important aspects of interest to all concerned. Such consolidation would effect simplified manufacture, more reasonable prices, and better availability of satisfactory tubes, and in time of war the United States would have a powerful, experienced electronic equipment and tube manufacturing asset that could make peace-to-war transition with a minimum of confusion and loss of time.

It is not possible here both to cover the Signal Corps research and development program and to give pertinent results, but it is a general policy for us to make available to the Department of Commerce copies of the final reports which we receive on our unclassified projects, and which in turn are available at cost of printing. It is considered that this affords maximum return for the taxpayers' dollar consistent with considerations of national security.

Our tube program does include studies of filamentary alloys, ruggedization of specific types of tubes, and studies of methods of making accelerated life tests. Storage tubes have many important military applications but there are numerous industrial applications for these tubes. Crystal rectifiers are appearing in more and more electronic instruments and considerable basic research is being sponsored at university laboratories.

BELL SYSTEM

J. R. Wilson (*Bell Telephone Laboratories, New York, N. Y.*). The Bell System represents an early user of electron tubes in large quantities where reliability and long life are essential to attain the transmission service expected by the modern-day telephone user.

The reliability and long life of "telephone tubes" has been achieved by the co-ordinated efforts of the tube researcher and designer, the circuit designer, the tube manufacturer, and the equipment user. All of these functions are integrated in one organization. This has enabled eveyone concerned in any given project to evaluate his particular task not only in terms of the requirements in his special field, but also in terms of the overall system requirements of reliability and economy. An illustrative example of coordinated effort was given in which it was hown that in a certain system the tube ailure rate had been reduced to 0.6 per cent per year. The total tube replacement rate is about 6.0 per cent per year as many tubes are removed at scheduled test periods which experience has shown might degrade the performance of the system below an arbitrary transmission standard before the next test.

It was suggested that if ways could be found to disseminate the necessary information to all of the functional groups listed in the foregoing, the same type of end results could be attained by organizations whose interests of necessity must be under different managements.

It was pointed out specifically that reliability and long life in cathodes is obtained when cathodes are operated at constant temperature and that good regulated power supplies are therefore desirable. Also, it was pointed out that the higher the required electron emission per unit area of cathode, the shorter the cathode life. Although the life of high figure of merit tubes may be shorter in hours than that given in the illustrative example, reliable service can be obtained by more frequent test intervals.

Common Objectives in Electron Tube Development Program

A. Lederman (*Panel on Electron Tubes, Research and Development Board, New York, N. Y.*). The Panel on Electron Tubes is a supporting agency of the Research and Development Board. It is charged with the responsibility of insuring that the services' electron tube research and development program is adequate for our national security. The membership of the panel is drawn from both government and nongovernment sources; its technical secretariat is provided for by a contract between Columbia University and the Signal Corps, jointly supported by the Navy Department. Although the panel's field of interest includes all types of electron tubes, of particular concern is getting electron tubes to work under service hardship conditions. It is this phase of the program that is of prime interest to the conference on electron tubes.

The efforts of the current programs are directed towards improving the mechanical strength and increasing the life of electron tubes. Mechanical strength can be interpreted in a manner similar to the way the services described a rugged tube; the tests which a rugged tube must undergo for acceptance are defined in paragraph F-6b(9) of JAN-1A, and include a shock test estimated at 500 g for three-fourths millisecond. Long life operation of tubes requires in most instances that the tube shall operate for 10,000 hours. Several organizations have standardized on the JAN-1A specifications; this is desirable because it better defines the problem to the tube manufacturer. At present about 40 tubes are being ruggedized, including miniatures, voltage regulators, low power transmitting tubes, thyratrons, low power rectifiers, and subminiatures.

Although the program as it is formed now does not specifically contain the requirements of the specialized user groups in the instrumentation and industrial field, its secondary results probably will meet a good many of these requirements. The experience being gained by the manufacturer will permit him readily to incorporate desirable features in tubes according to specialized demands. Even at present many of the desired features, such as static electrical characteristics and tube to tube electrical similarity, are offshoots of the current tube programs, because such characteristics are dependent by large on a tube's construction, which is being refined.

One of the most important accomplishments of a conference of this kind is to present to the tube manufacturer evidence of sufficient interest in these higher quality tubes. The services through their ruggedization program have expressed such interest, and other consumer groups have too. In recognition of an increasing demand, many tube manufacturers already are giving major attention to the development and production of high quality tubes. The prospects for the availability of tubes for instrumentation and industrial use in the near future appear very bright.

Manufacturers' Policy With Relation to Special Tubes

W. R. G. Baker (*General Electric Company, Schenectady, N. Y.*). Electron tubes for industrial purposes present the tube manufacturer a tremendously varied set of problems. The committee should unify and crystallize the needs of industrial users and provide tube manufacturers with the detail information necessary to permit a reasonable solution of some of the problems.

Tube manufacturers know that they can provide the tubes required for industrial application despite the basic difference between that and the entertainment field.

The approach, early in tube industry history, to produce a line of high quality special tubes might have succeeded had the market been conditioned to the use of tubes and had proper relations existed between the tube and equipment manufacturers. The majority of these early attempts at commercialization failed for economic reasons.

A later approach to the problem which appeared to offer real possibilities was selection from mass-produced receiving tubes. This made available a special tube but the process developed basic weaknesses, caused by the wide divergence in the technical and economic requirements of the two markets.

The broadcast-receiver market, nearly 150 million tubes per year, is extremely competitive and the producer is concerned with tenths of cents. Cost and production considerations require a high degree of mechanization, hence, considerable investment both in plant and exceptional machine facilities. As the facilities must be operated at the maximum possible load and with the greatest efficiency, small production runs and special tubes must be avoided.

Considering the complexity of electron tubes the quality and uniformity of the product is high.

The survey of industrial markets indicates that about 1,230,000 tubes would be required at an average price of two dollars each. From the production viewpoint this represents a job-ship operation.

Technically, tube manufacturers should consider two factors. First, a considerably higher degree of reliability than is required for broadcast receivers. Second, furnishing the equipment designer sufficient information to permit him to design for long and reliable life.

We should distinguish between long life and reliable life. Long life, to a tube manufacturer, implies that, considering a large number of tubes, the average life of the product is long. This is not the performance desired by equipment designers.

Reliable life, on the other hand, means a small percentage of failures over a specified period. Thus one of the problems to be solved is a method of eliminating early failures and we again are faced with an economic question. Certainly there is an economic optimum as to the percentage of failures that can be tolerated in, for example, the first 10,000 hours. As this percentage is reduced, the cost to insure it will be almost inversely proportional.

The wide diversity of industrial applications necessitates a very fundamental specification which, to mean anything, must apply during the entire useful life of the tube. To establish such specifications, many life tests over a long period of time will be required.

Assuming that tubes designed for broadcast-receiver use cannot be applied in industrial applications, tube manufacturers have the problem of facilities for special tubes with consequent segregation from normal tube production. This means additional investment in plant and mechanical equipment as a handmade product probably would not be acceptable.

If industrial electronics is to be a business instead of an art some basic problems must be resolved. To this end certain recommendations can be made.

1. Close liaison between tube and equipment manufacturers.
2. Appreciation that special tubes are more expensive than a mass-produced product.
3. The number of types should be kept to a minimum to provide the maximum quantity per type.
4. Tube manufacturers must provide complete information for guidance of equipment manufacturers.
5. Equipment manufacturers, whenever possible, should use mass-produced tubes.
6. Equipment manufacturers should avoid all unnecessary requirements.

From such a plan there should result a sound industrial electronic business which will grow in a satisfactory and orderly manner.

Improved Electron Tubes for Instrumentation and Industrial Use

DESIGN CONSIDERATIONS

N. H. Green (*Radio Corporation of America, Harrison, N. J.*). The principal objectives in the design of industrial tubes are stability of characteristics, uniformity between tubes, mechanical strength, and long life. The *5691*, *5692*, and *5693* are new RCA tube types of receiving-tube size which are designed to meet these objectives.

These new industrial tubes are designed to operate with a relatively low cathode temperature to minimize leakage and grid emission.

The control-grid wires are silver-plated to provide improved heat conduction and to reduce variations in contact potential. The electrodes are fitted tightly in the supporting mica insulators and the cathodes are locked to the top micas by a pinch-weld operation which insures low microphonic qualities. All tubes are operated with full voltages for several days to stabilize characteristics before final testing.

A high degree of uniformity is maintained by gauging parts at the assembly unit and segregating them into zones. This procedure permits narrow ranges of control limits and minimizes unbalance in characteristics between the units of the double triodes. The number of factory control tests performed is increased greatly.

Ruggedness is obtained by constructions which lock the electrodes securely to the insulators, support the electrode assembly rigidly from the button stem, and extend the mica insulators to contact the inner wall of the envelope. A tight fit of the micas on the electrodes is stressed to prevent chafing of the micas under vibration.

Heaters for the industrial tubes are of the double-helical coil type because it has low hum qualities and resists shock. The heater legs are prewrapped with nickel tubing to increase the strength of the weld to the nickel stem leads.

Long life is obtained by thorough inspection of all parts and processes, by careful assembly, and by rating the tubes conservatively.

MANUFACTURING CONSIDERATIONS

N. L. Kiser (*Sylvania Electric Products, Inc., Emporium, Pa.*). The results of the electron tube survey pointed out that the improvements on present-day receiving tubes which are desired by the industrial equipment manufacturers can be summed up as follows.

1. (*a*). Improved life or uniform characteristics.

(*b*). Greater stability of the electrical characteristics during life.

(*c*). Lower noise output and greater ability to withstand vibration and shock.

2. In speaking of improved life it was pointed out that if life averages were to be 5,000 to 10,000 hours present designs are readily adaptable. Anything over 10,000 hours life would require totally new design techniques.

To reach the goal which was asked for manufacturing techniques would have to be changed completely. The desirability of having the operation completely divorced from normal high speed receiving tube production was desirable. The places wherein manufacturing techniques would have to be changed can be summed up as follows:

1. Tighter tolerances on tube parts.
2. Rigid quality control on all parts.
3. Slower mounting standards.
4. Slower exhaust specifications.
5. Longer aging schedules.
6. Preburning for life aging.
7. Narrower limits on testing specifications.
8. Maintenance of a higher quality level at testing.

The paper covering rectifiers similar to type *6X5GT* pointed out that a tube already had been developed by Sylvania Electric Products Inc. carrying type number *1274* would meet the requirements as set forth by the electron tube survey. Very little discussion regarding this type was held, although considerable interest on the part of numerous manufacturing companies was forthcoming. It further was pointed out that additional technical data and sample tubes could be procured by contacting the Sylvania Company.

ECONOMIC CONSIDERATIONS

N. B. Krim (*Raytheon Manufacturing Company, Newton, Mass.*). The tube industry, as a whole, would have to invest from $600,000 to $1,700,000 in engineering, capital equipment, personnel training, and capital to finance inventories to produce the tubes which have been called for in the AIEE long life tube questionnaire in the $5 and $2 markets. These figures do not include any capital for buildings or standard tube manufacturing equipment currently available in present tube plants. The hypothetical costs on the nine special purpose types which were called for in quantities of more than 1,000 per year are discussed in the next paragraph to illustrate the effect of production volume on write-off of engineering development, capital equipment, and so forth. These estimated hypothetical costs might vary by as much as plus 100 per cent and minus 50 per cent throughout the tube industry.

The total cost per tube for a production of 1,100,000 tubes per year spread over the nine types is estimated at $1.67 per tube. This figure increases to $2.28 per tube for 550,000; $3.03 for 260,000; $4.54 for 130,000; and $6.68 for 65,000 tubes annually. The foregoing cost figures are based on writing off engineering development over five years, tube-making equipment over eight years, and personnel training over $2^1/_2$ years. They also included factory overhead at 200 per cent of direct labor, and nine new production setups per year.

The foregoing figures indicate that if these hypothetical costs are correct, the four or five highest volume types shown on the survey might be made available profitably by one or two companies in the $4 to $5 equipment price bracket. These types might drop to $3, or even less in a few years, when the engineering investment is written off, when the factory costs are known more accurately, and when the market expands to several times its present size.

Open Forum on Electron Tubes for Instrumentation and Industrial Use

DESIGN DETAILS—BASING, ENVELOPES, AND SO FORTH

C. W. Martel (*Raytheon Manufacturing Company*). The questionnaire indicated that miniature, glass, and metal tube constructions were preferred in that order. Among the advantages and disadvantages of each type of construction are the following considerations:

1. The miniature construction has the advantages of small size and light weight which makes it easy to ruggedize. The elimination of a base as well as other constructional features makes it better at high frequencies. The miniature construction is readily available, is well suited for automatic production operations, and tube manufacturers have accumulated a lot of helpful "know-how." Disadvantages with the miniature construction are based on the fact that its all glass design requires special care to prevent glass strain and possible cracks or breakage. This includes the use of well designed sockets and special shields to hold the tube in the socket. Its voltage handling and power dissipating abilities are poorer than those of larger tubes.

2. Standard glass tubes have the advantage of ready availability in many standard constructions and sizes to fit particular requirements. Here also there is a wealth of manufacturing "know-how." The use of separate bases reduces glass strain problems and aids in obtaining better socket holding power, but increases the possibility of leakage. This type of construction has greater voltage and power dissipating ability, but its maximum frequency characteristics are poorer. The tubes are generally larger and less easy to ruggedize.

3. Metal tubes have the advantage of greater strength than either miniature or standard glass. Generally metal tubes are reasonably small and light with the additional advantage of good electrical shielding. However, they also have poorer frequency characteristics than does the miniature construction and the use of separate bases increases the possibility of leakage.

Other design factors which should be kept in mind are

1. The desirability of low heater voltage to reduce hum. In some cases special heater designs are desirable.

2. Care in processing the grids to reduce grid emission.

3. Care in designing the plates to facilitate degassing during production and adequate radiation when the tube is in operation so that they will not become hot enough to release gas.

It was suggested that thought be given by the engineers present to what is meant by a 10,000-hour tube. There is an appreciable engineering difference between making tubes which will all be good until 10,000 hours compared with making tubes such that no more than perhaps two per cent, or three per cent, or five per cent will have failed at 10,000 hours. The end of life requirements also must be determined for each application, but consideration should be given to the present RMA (Radio Manufacturers Association) standards.

D. B. Fisk (*General Electric Company, Schenectady, N. Y.*). It is particularly interesting to note the limits suggested for quantities not ordinarily tabulated in the more common tube manuals. For instance, the engineer designing measuring devices, who is limited for economic and commercial reasons to the selection of standard receiving type double diodes, has proceeded with some doubt in his mind as to the unlisted vagaries of the tubes. To avoid production and field problems in his application, he has resorted to circuitry and selecting voltage levels, at some added expense, to minimize potential difficulties arising from variations in these tube characteristics.

The conversion of alternating current to direct current in measuring circuits employing diodes and associated d-c instruments always has included a troublesome and somewhat indefinite problem of unwanted diode current and instrument current, in widely varying amounts, in the absence of plate voltage. The limits on plate current at zero volts as proposed at least will resolve this problem and give the designer established values on which to base designs. The spread of the final limits will determine whether the tube or the nonthermionic diode will be selected for the application.

There were shown proposed values for plate current at zero volts with 40,000 ohms load per plate. In this regard, one question which might be asked is: what variations in current for other plate loads, percentage-wise, may be expected?

This matter of current at zero volts apparently is not a problem for many users, but it is certainly of intense interest to those engaged in the design of measurement circuits.

Referring to the proposed characteristics, the question arises as to whether characteristics should be listed for heater voltages other than the nominal value. It would seem advantageous to do so.

The proposed table lists plate current (at 20 volts direct current) per plate. Now it may be that these two quantities determine the dynamic plate resistance of the tube at that point, regardless of construction. Whether or not this is so, this value probably should be stated, at least nominally. Certainly the user is interested in changes in current causes by changes in plate voltage.

TWIN DIODE

C. R. Knight (*General Electric Company, Schenectady, N. Y.*). The characteristics of the desired twin diode are as follows:

1. Tube life—9,000 hours
Characteristic determining end of life:
(*a*). Plate current
(*b*). Balance

2. Most constant lifetime characteristic and permissible variation:
(*a*). Plate Current plus or minus 12 per cent
(*b*). Balance plus or minus 10 per cent
(*c*). Interelectrode capacitance plus or minus 10 per cent

3. Most uniform characteristic between tubes and permissible variation:
(*a*). Plate current plus or minus 11 per cent
(*b*). Balance plus or minus 14 per cent
(*c*). Interelectrode capacitance plus or minus 10 per cent

4. Items needing improvement:
(*a*). Hum
(*b*). Noise level
(*c*). Microphonics

5 Unusual service operating conditions:
(*a*). High temperature (150 degrees Fahrenheit)
(*b*). Excessive shock
(*c*). Excessive vibration (10 g)
(*d*). Low pressure (3 inches Hg)
(*e*). High humidity (95 per cent)
(*f*). Low temperature (−50 degrees Fahrenheit)
(*g*). Exposed to chemicals
(*h*). Excessive dirt

6. Preferred type of envelope:
Miniature glass

7. Other characteristics requested:
(*a*) Notice of withdrawal from the market should be given ten years before withdrawal takes place.
(*b*). Lower leakage between heater and cathode.
(*c*). More rugged construction.
(*d*). Higher d-c heater-cathode potential rating desired (preferably 450 volts).
(*e*). Closer tolerances on physical dimensions (secondary importance).
(*f*). Greater uniformity and stability of contact potential.

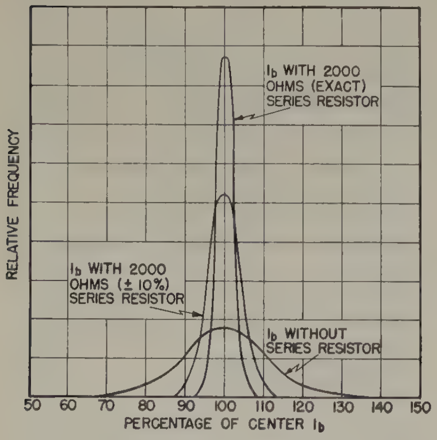


Figure 1. Frequency distribution of plate current of type *6H6* twin diode (each section) with and without series resistor

E_{bb}=20 volts E_f=6.3 volts

A few changes in the data taken from the questionnaire have been made in the interests of consistency.

Plate current variations, initially and during life, in the commercial type *6H6* are largely attributable to random variations in the emission from the oxide-coated surface. Although by very careful processing control, some reduction of the dispersion of plate current might be realized, it would be relatively small and the final results unreliable. The probability of plate current's drifting outside this range during life would be very high. Figure 1 shows the distribution of plate current (I_b) on typical commercial *6H6* production and the effect that a 2,000-ohm series resistor has on this distribution. This resistor reduces the effective dispersion in diode plate current for a given applied voltage to where almost all the commercial product would be acceptable on the basis of a plus or minus ten per cent allowable variation, even when a plus or minus ten per cent tolerance resistor is used. If it is fundamental that the tube itself should have the plus or minus ten per cent dispersion indicated, it is certain that a pure-tungsten-filament tube could meet these requirements with relative ease because of the more uniform emissive properties of tungsten. Oxide-coated cathode tubes probably would give a marginal or unacceptable product considering the current state of the art. By minimizing tube drop variations through circuitry, the oxide-coated cathode product can be made very acceptable. The advantages of the oxide-coated cathode, from the standpoint of circuit use and emission efficiency, are well known.

From the statistical nature of the plate-current variations, it is apparent that plate current and diode balance are related very closely and that there is a slightly smaller dispersion of diode balance than on actual plate current distribution. The previous discussions referring to plate current also will apply to diode balance, with the exception that diode balance on the average will not be expected to change materially during life.

Tubes similar to the *6H6* easily could be made within the capacitance tolerances specified.

Heater-cathode leakage is important in industrial applications. Much research and advanced development effort currently is being applied to advance the state of the art in this direction. Until such time as answers can be found to some of the existing problems, cathode resistance should be kept to reasonably low values. It is well to realize that heater-cathode currents as small as 0.05 microampere through 20,000 ohms resistance can result in hum voltages of a millivolt. Most tube manufacturers making the type *6H6* and *6AL5* for frequency modulator discriminators have hum tests on their product at about this one millivolt level.

Mechanical requirements such as low microphonics, ability to withstand high temperature, and shock and vibration can be met, within reasonable limits, by mechanical redesign. Higher d-c heater-cathode potential ratings up to 450 volts undoubtedly can be applied because existing receiving tubes are available which meet this requirement. To obtain such ratings with the high degree of reliability desired means sacrifice of some characteristics of secondary importance, such as cathode warm-up time. Much higher d-c leakage also might be expected.

Greater stability and uniformity of contact potential can be provided only to a very limited extent with means available. The factors in tube manufacture which control contact potential, are understood only partially. The General Electric Company's research laboratory has been working on this problem for quite some time.

Tube life is questionable. Does 9,000 hours tube life mean that 100 per cent of the tubes should operate 9,000 hours or that the average life of the tubes can be 9,000 hours? Logically, it would appear that some small percentage, for example 10 per cent only, are allowed to fail in the 9,000-hour period. From a technical standpoint, a tube can meet this last requirement. Experience has shown that an appreciable number of early life failures can be eliminated by operating tubes from perhaps 50 to 500 hours. Failures resulting from mechanical causes, such as burnouts, interelectrode short circuits, and so forth, can be reduced by design improvements and rigid inspection during manufacture. The cost involved in improving survival characteristics may vary inversely as the number of allowable failures.

TWIN TRIODE—MEDIUM MU

C. C. Chambers (*University of Pennsylvania, Philadelphia, Pa.*). One of the items on the hypothetical characteristic sheet that I would like to raise question about is the 10,000-hour life. A little experience that we have had in connection with the ENIAC would be very useful. It has been mentioned that the failures of tubes during the first few hours of life are much larger than they are later throughout life. In our experience with the ENIAC we have observed that fact. About half of the 18,000 tubes in that device were *6SN7*'s. They were used in operation of trigger circuits, counter circuits, and switching circuits of that general nature. In planning the device it was considered that the device would be economically useful if we could count on an average life of 2,000 hours and a failure which was linear throughout that lifetime and replacing each tube—all tubes—at the end of 2,000 hours.

Actually in operation we have found that after the first 100 hours when there is an excess of failure that the failures from then on seem to be almost uniform. That is, week in and week out the number of failures is unchanged. However, we have run the computer with the same set of tubes up to about 2,500 hours at which time a complete change in tubes was made, solely because we anticipated that we might get into trouble. However, if you predict the average life of a tube on the basis of failures per week or per month after the first 100 hours, we find that the average life of the ordinary *6SN7* is between 100 and 200 years. Consequently, the 10,000-hour life has a very questionable meaning.

A characteristic that is also quite important is the one which says that if the tube has ten milliamperes plate current at zero grid bias, what is the variation in grid bias at which that plate current falls to 1 or 1/2 milliampere? The reason for that specification being so important is that in all of the trigger circuits and in all the switching circuits the operation in the region cutoff, or from beyond cutoff to the normal operating region of the tube is of very critical importance.

C. M. Morris (*Radio Corporation of America, New York, N. Y.*). The RCA *5692* is a medium-mu twin triode similar to the *6SN7-GT*. The basing of this tube corresponds to the *6SN7-GT*. The one difference is that the heaters for the separate units of this type are connected in series. In many applications, and particularly in balanced amplifier controls, this is a very desirable feature because it will render both sections inoperable simultaneously if the heater of either unit fails. At this point, it might be well to compare the characteristics of the *5692* with those of the hypothetical medium-mu triode. With the exception of some minor differences the *5692* will fulfill most of the proposed requirements. One of the differences is the choice of base and envelope size. There is no reason to believe that a high mu triode in a miniature bulb would not perform the desired functions. However, the choice of envelope for the *5692* was based on more than ten years of accumulated life test data. It is believed that the change from the *GT* bulb to the miniature tube would deprive the tube of its background and the necessity of starting a new investigation on the minature long-life program. It would require at least two years before you would have any background or information established to base long life on.

One other item that was on the hypothetical sheet was the withdrawal policy. It requires that at least ten years notice be given before the tube is withdrawn from service. This policy would put no undue burden on manufacturers, especially if the production of any one type was relatively low. If the tube type had a large enough production and the renewal sales was of a volume that would require the production of the tube for ten years after its withdrawal notice was given, I think it could be maintained. The alternate method would be for the instrument manufacturer after a removal notice was given to stock up on tube types. Buy a 10-year supply and put them on the shelf. Obviously, that would not be a very economical process.

With respect to the electrical data we differ in one respect. The limit for the *5692* so far as transconductance is concerned has a range of 1,825 to 2,575 or plus or minus 17 per cent. The proposed tube has the limits of 1,950 to 2,450 or plus or minus 11 per cent. Tightening of the limits to this extent which is a difference of six per cent would require that in the manufacturing process we would go at least two per cent or three per cent inside of that to make sure that the tubes would meet the required limits. Therefore, we would have to manufacture our tubes to less than 11 per cent. It has been brought out that so many thousand tubes will be bought at $5 a tube, so many at $10 a tube, and so many at $2 a tube. You would have to strike an economical balance between characteristics and cost. It is believed that if we were to tighten up to the requirements of the hypothetical tube, the cost would go up not just ten cents per tube but it might even double. It is not a case of just pulling in the limits a little bit, but trying to get a quality tube and as you approach 100 per cent perfection, or 95 per cent perfection, or whatever you want to take it, the cost of the tube increases very rapidly and, therefore, we do not believe that the actual change of 17 per cent to 12 per cent would be a serious handicap so far as the *5692* is concerned.

PENTODE VOLTAGE AMPLIFIER

W. H. Tidd (*Bell Telephone Laboratories, New York, N. Y.*). Transmission measuring instruments use pentodes principally for voltage gain. Transconductance, therefore, is the characteristic which should be the most stable with life and the most uniform.

In test sets, precision is an important consideration, and frequently it is desirable to have a precision of plus or minus one to two per cent.

To maintain the desired precision of an instrument it is necessary to calibrate at suitable intervals, or to incorporate in the design sufficient negative feedback to stabilize the sensitivity for the expected changes in the transconductance of the tubes. It is apparent that improving transconductance stability lengthens the calibration interval for sets without feedback. The advantages of transconductance stability are more impressive in instruments using negative feedback. Here the gain which must be used as feedback to obtain a certain stability is less for stable tubes, leaving more useful gain. This even may reduce the number of tubes needed, which reduces the instability and the cost at the same time.

In a 3-tube amplifier a decrease of 10 per cent for each tube would amount to 2.7 decibels. Twenty-six decibels of feedback would reduce this variation to about 0.15 decibel. Compare this with a 35 per cent reduction per tube or 11 decibels for the amplifier. Forty-three decibels of negative feed-back would be required for the same stability, a 17-decibel penalty.

The foregoing considerations indicate that a ten per cent variation of transconductance over the life of a tube should be a distinct improvement from the instrument maker's point of view.

The fluctuation of the transconductance with changes in the heater voltage is another variable which should be held to as low a value as possible, possibly two or three per cent with a ten per cent line voltage fluctuation.

Second in importance is the tolerance from tube to tube. In an instrument which does not utilize negative feedback, it probably will be necessary to recalibrate the instrument when tubes are changed. In instruments where negative feedback is used for stabilization, changing tubes would be unlikely to cause a change of more than a few per cent with a ten per cent tolerance on transconductance.

It hardly needs to be stated that long life is desirable for tubes in electronic instruments. The time required for maintenance will become excessive if the tube life is short, especially in instruments employing a large number of tubes. A tube life of 10,000 hours should make most intermittently used test sets last for several years.

While the *6SJ7* tube was chosen to represent the voltage amplifier pentode for the purposes of the subcommittee survey, there is an increasing need for tubes more suitable for broad-band amplifiers. Therefore, it would be desirable to include an improved tube having a G_m of 5,000 or higher, such as the *6AK5* or *6AC7*, in any line of improved tubes for instrumentation.

MULTIGRID CONVERTER

C. Everett Coon (*Tung-Sol Lamp Works, Inc., Bloomfield, N. J.*). The pentagrid type of receiving tube has received relatively modest usage in the industrial field. However, its major industrial application is believed to be quite different from the use for which it originally was designed and tested. Tubes of the *6SA7* class are intended for combined local oscillator and mixer service in superheterodyne receivers. By virtue of its two independent and well shielded control grids, this tube has been used in such varied applications as vacuum tube voltmeters, complex-wave analyzers, switching and gating devices, as well as various types of modulators. Under these conditions it is obvious that the tube manufacturer cannot assure adequate control of all required characteristics in addition to the demands of stability during life and resistance to mechanical shock and vibration.

It appears logical, then, to propose the development of more specialized tubes which would fulfill at once the mechanical requirements and have their electrical characteristics more nearly fit the major circuit applications. Two such versions of the pentagrid tube may be sufficient. The first could be a redesign of the present *6SA7* for communications use, and the second could be a tube better adapted to switching and gating use. The latter would be characterized by a resign of the two control grids to provide for the strict control of their characteristics from cutoff through the positive grid region.

Having established the electrical ratings of these hypothetical tubes, consideration must be given to those demands imposed by the continuity of service which industrial usage demands. Fundamentally, their construction is no more difficult than that of other voltage amplifiers of comparable size and dissipation. As type *6SJ7* recently has been redesigned successfully for industrial use, it is fair to expect that the same results could be achieved with the pentagrid. However, the use of two independent control elements may require a somewhat broader initial spread of electrical limits than those of the *6SJ7* type. It appears quite feasible to employ either the minature, GT glass, lock-in, or metal tube construction in achieving the end result.

G. B. Hoadley (*Polytechnic Institute of Brooklyn, Brooklyn, N. Y.*). The pentagrid converter finds use in two quite distinct applications. In one use, the tube accomplishes frequency conversion, changing the carrier frequency from one value to another. In the other use, the tube acts as a gated amplifier.

Unfortunately, the survey questionnaire was not designed with the converter in mind. For example, the characteristic expressing the tube's ability to perform frequency conversion is the conversion conductance, but this was not specifically mentioned on the questionnaire, and few returns were received in which there was a specific request for consideration of conversion conductance as a controlling factor. Instead, mutual conductance was rated as of first importance! This might be interpreted as meaning conversion conductance, but the small number of comments on this point leads the committee to disregard this possibility.

Of all the tubes on the questionnaire, the converter is the one whose performance most intimately is associated with the circuit in which it is used. Because of the large number of electrodes, there are so many different currents and voltages which enter into the operation of this tube that it becomes a most difficult matter to establish test conditions and tolerances which adequately will separate those tubes which will give satisfactory service from those which will not. The performance of tube and circuit are so closely interrelated that the best test circuit for a converter is the circuit in which it is to be used. It is hoped that discussion will disclose the various needs for a tube of this type and thus will show the direction in which the committee should proceed.

BEAM POWER TETRODE

R. L. McCormack (Raytheon Manufacturing Company, Newton, Mass.). The following ratings represent a hypothetical beam power amplifier tube similar in many respects to the *JAN 6L6G*, but rated more conservatively to improve life performance.

Class: beam pentode—ruggedized, 10,000-hour life, 10-year withdrawal notice

Mechanical data:

Envelope—*ST-16*, glass
Base—octal 7 pin
Maximum diameter—2$^{1}/_{16}$ inches
Maximum over-all length—5$^{5}/_{16}$ inches
Maximum seated height—4$^{3}/_{4}$ inches
Pin connections:
  Pin 1—no connection
  Pin 2—heater
  Pin 3—plate
  Pin 4—grid number 2
  Pin 5—grid number 1
  Pin 6—heater
  Pin 7—cathode
Mounting position—any

Electrical data:

Ratings:
  Heater voltage alternating or direct—6.3 volts
  Maximum plate voltage—275 volts
  Maximum grid number 2 voltage—275 volts
  Maximum plate dissipation—15 watts
  Maximum screen dissipation—2.5 watts
  Maximum d-c plate current—75 milliamperes
  Maximum d-c grid number 2 current—10 milliamperes
  Maximum d-c grid number 1 current—5 milliamperes
  Maximum d-c heater-cathode voltage—+180 volts
  Maximum negative grid bias—−100 volts
  Maximum grid circuit resistance—500,000 ohms
Characteristics and range values:
  Heater volts, 6.3; plate volts, 250; grid-number 2 volts, 250; grid-number 1 volts, −14; heater-cathode volts, +100.

	Minimum	Average	Maximum
Heater current, amperes	0.840	0.900	0.960
Heater-cathode current, microamperes	0		75
Grid current, microamperes	0		2.0
Plate current, milliamperes	55	65	75
Plate current (for grid voltage of −50 volts direct current), milliamperes	0		1.0
Screen current, milliamperes	2.0	4.5	7.0
Transconductance, micromhos	4,800	5,400	6,000
Power output, watts	5.0	5.9	

Expected tube life is indicated as 10,000 hours. This may not be unreasonable judging from the performance of standard *6L6G* in computers where, it is reported, they have been reasonably satisfactory for 8,000 hours when operated conservatively. Our experience at Raytheon in connection with a Bureau of Standards contract on long life *6SN7GT* for computer use has led us to the conclusion that the emission life of a vacuum tube is a function of cathode operating temperature and current drain. In general, the lower the current drain per square centimeter of cathode area, the lower the temperature at which the cathode may be operated without poisoning and the longer the life expectancy of the tube.

The mechanical life expectancy of a tube, however, is a function of design and assembly techniques. Design knowledge is acquired only through experience and assembly techniques are a combination of engineering experience and operator training.

We believe that this beam power output tube can be produced with a reasonable electrical life expectancy of 10,000 hours by redesigning and rerating for conservative operating temperature and drain. Good mechanical life best can be assured by high volume production.

The suggested *ST16* bulb is more reasonable than the requested miniature bulb, because of the high anode dissipation required in this tube.

The term "ruggedized" used here is not defined, but we would expect the structure could be made rigid enough in an *ST16* bulb to withstand the shock and vibration requirements of commercial service.

These ratings indicate an initial plate current spread of plus or minus 15 per cent. We believe this spread in characteristics can be obtained, with some extra cost, by tightening up on grid dimensions and taking additional care in the assembly operations. To reduce the characteristic spread much beyond this point requires either new manufacturing techniques, beyond the present state of the art, or tube selection. New manufacturing techniques probably would require more funds for research than the sales volume on the type would permit. Selection is possible, though costly, but even here there is a practical limit in that the plate current will vary with life. Thus, although it would be possible to select tubes to a very narrow plate current range initially, the change during operation is not controllable within narrow limits with our present knowledge of the art. This same reasoning applies to transconductance spread. The survey indicates that the most constant lifetime characteristics desired are plate current and transconductance. The change during life suggested, plus or minus 11 per cent for plate current and plus or minus 8 per cent for transconductance spread during 10,000 hours of operation appear to be too tight, but we have no experience to guide us here. A lower limit on both characteristics of say 75 per cent of their rated values might be reasonable as an end of life point.

Some improvements could be made undoubtedly in leakage hum, microphonics, and noise level. These are largely design considerations and the improvement obtainable would be limited by the cost of research relative to the expected sales volume and unit price. The same comment applies to the request to improve tube performance under conditions of high and low temperature, high and low pressure, high humidity, shock, and vibration. These improvements are all probably possible to achieve, but economic considerations are the determining factors.

We have had in mind an estimated development cost of $10,000–$12,000 to produce a tube to meet the ratings shown. The survey indicates a possible gross income varying from $4,700 to $11,000 per year dependent upon tube price. This volume does not permit much more development cost than this even though this volume might be guaranteed one tube manufacturer for a 10-year period.

POWER TRIODE

R. L. McCormack (Raytheon Manufacturing Company, Newton, Mass.). The ratings shown on the power amplifier triode are very simila to the *JAN 6A3* and *6B4G*. They are a follows:

Class: power triode—ruggedized, 10,000-hour lif 10-year withdrawal notice

Mechanical data:

Filament—coated, directly heated
Envelope—*ST-16*, glass
Base—octal 8 pin
Maximum diameter—2$^{1}/_{16}$ inches
Maximum over-all length—5$^{5}/_{16}$ inches
Maximum seated height—4$^{3}/_{4}$ inches
Pin connections:
  Pin 1—no connection
  Pin 2—filament
  Pin 3—plate
  Pin 4—no connection
  Pin 5—grid
  Pin 6—no connection
  Pin 7—filament
  Pin 8—no connection
Mounting position—any

Electrical data:

Ratings:
  Filament voltage alternating or direct—6.3 volts
  Maximum plate voltage—300 volts
  Maximum plate dissipation—15 watts
  Maximum plate current—80 milliamperes
  Maximum grid current—5 milliamperes
  Maximum negative grid bias—−150 volts
  Maximum grid circuit resistance—100,000 ohms
Characteristics and range values:
  Filament volts, 6.3; plate volts, 250; grid volt −45

	Minimum	Average	Maxi- mu
Filament current, amperes	0.90	1.0	1.
Grid current, microamperes	0		3.
Plate current, milliamperes	52	62	7
Plate current (for grid voltage of −100 volts direct current), milliamperes	0		1.
Transconductance, micromhos	4,300	5,400	6,50
Power output, watts	2.8	3.2	
Amplification factor	3.8	4.2	4.

Here again, a 10,000-hour life expectanc is indicated. Although we have had no long life experience on tubes of this class, shor term life has been found unusually good o the present design. We would expect 10,000 hour operation would be obtainable with only minor design changes.

Again, the *ST16* bulb, rather than th miniature envelope requested, is recommended because of the high plate dissipatio required. An octal base has been suggeste presumably more for reasons of standardization than performance. A 4-pin base migh be better for leakage for high humidity, lo pressure, and dirty location operating conditions.

The most uniform characteristic betwee tubes as shown by the survey is a plate sprea of plus or minus 6$^{1}/_{2}$ per cent. The hypothetical design allows plus or minus 16 per cen spread while the *JAN 6A3* specification permits plus or minus 32 per cent. The plat current spread of any triode is dependen upon the accuracy with which the filament to-grid and grid-to-plate spacings can b maintained. The plate is a die-formed par and experience has shown that dimensiona variations in plate diameter off the die, o after restriking, of plus or minus 0.002 inc are the best that can be expected with presen techniques. This tolerance is widened during tube processing when the plate deform under heat treatment. Grids are wound o special lathes which may permit at best plu or minus 0.001 inch diameter variations wit an additional plus or minus 0.0005 inch off center tolerance. These tolerances agai are widened during heat treatment in tub processing. The micas used for spacing th electrodes are punched to tolerances no bette than plus or minus 0.0005 inch and tolerances must be left in the size of the holes to accommodate diameter variations in the wire supports which are inserted into them. Even the best assembly techniques result in some parts distortions. Now, if all these tolerances, representing the best known techniques are considered together the possible variations in element spacings would produce plate current variations in a triode of this type in excess of the plus or minus $6^1/_2$ per cent requested. The plus or minus 16 per cent indicated on the rating sheet is nearer to what we could expect to accomplish with present techniques.

The most constant life time characteristic requested is mutual conductance with a spread of plus or minus 23 per cent. If this figure means the allowable variation on an individual tube of plus or minus 23 per cent, it is quite attainable. We have assumed, however, that this figure represents the maximum deviation from design center during life. As our initial spread on transconductance is given as plus or minus 20 per cent, the plus or minus 23 per cent spread during life is not considered practical. We again would suggest a figure of about 75 per cent of the design center rating of the tube as an acceptable end of life point.

The grid voltage cutoff characteristic at plus or minus 6 per cent is listed as second in the order of preference for most constant lifetime characteristic. A cutoff limit of 1 milliampere at minus 100 volts has been suggested as possible on the hypothetical tube. Is it this type of characteristic which the requestors had in mind or a rating which would tie down the shape of the plate current curve for large signals? The cutoff characteristic at minus 100 volts would not change appreciably during life if proper precautions were observed to eliminate the effects of change in activity of the ends of the filament above and below the grid. The plate current at an intermediate bias would be expected to change in about the same percentage as the rated plate current.

It also is requested that interelectrode capacities should be held constant during life. We would not expect much change in capacities during life but wonder in what applications this feature is required.

In regard to the items needing improvement, hum, noise level, and microphonics all are rated as important. We would expect a 2.5-volt construction to be superior to the 6-volt type for hum and vibration because of the heavier ribbon in the filament. In the 6.3-volt type, the series filament construction might be poorer for hum because of the inherent unbalance in bias between the two grids as a result of filament drop along the filament. A parallel filament construction would avoid this bias unbalance, but might be poorer for hum because of lower heat inertia resulting from the lower weight filament ribbon employed in this construction. An indirectly heated cathode-type tube similar to the *6A5G* might be the best answer if hum and microphonics are major considerations and quick heating is not essential.

The questionnaire indicates the desirability of improving this excessive type for vibration and low pressure operating conditions. The present *6A3* will withstand 2.5 g vibration satisfactorily, but it may be questionable if 10 g operation can be obtained without radical redesign. The indirectly heated cathode type again might be the answer here. For low pressure operation, we have no data, but the 4-pin base, rather than the octal base, would give greater lead spacing in the socket and might be preferable.

Rudolf Feldt (*Allen B. DuMont Laboratories, Clifton, N. J.*). Results of the tube survey have shown that the large consumers desire this power tube in minature bulb. It seems highly doubtful that this may be feasible and discussion is invited.

The large users also have shown a surprising interest in close tolerances of electrode capacitances. This clearly indicates use of this tube as oscillator. Discussion is invited.

The survey further has shown that the most urgently required improvements are hum and microphonics. It also shows that excessive vibrations take the first place in unusual service conditions. In conclusion, the author suggests the use of an indirectly heated tube type similar to the *6A5G* instead of the *6A3* type originally suggested.

GASEOUS VOLTAGE REGULATORS

A. J. Williams, Jr. (*Leeds and Northrup Company, Philadelphia, Pa.*). The voltage regulator tube is of great importance to instrument manufacturers because it provides something which is constant, and that is important in making a measurement. It is sometimes necessary to have a per cent constancy in the voltage supply better than the per cent constancy sought in the measurement. For example in photometric work, the voltage across the tungsten lamp must be several times more constant than the desired light output. The output of a direct-coupled d-c amplifier (when operating on low ranges) easily may go from positive to negative with a fraction of a per cent change in the d-c supply voltage.

With this in mind the hypothetical data may be considered. An operating voltage is desired which has a minimum change:

1. From tube to tube.
2. For any one tube through its life.
3. For variation of current through any one tube.

This last change, which is called regulation, generally can be made smaller than the change from number 2, or from number 1, hence is specified separately on the hypothetical data. For a single tube circuit this regulation figure alone limits the change in output voltage for changes in load current or line voltage. With more elaborate regulating circuits using rheostat tubes, the current through the regulator tube may be held constant by its own action and for this application the regulation figure on the voltage regulator tube can be several times greater without adverse effect. For this application operation at lower current is preferable. One manufacturer already has done some work on this problem.

The subject of regulation brings up the subject of abrupt changes of tube voltage, resulting from any cause. The replies to the questionnaire comment on this, and indicate the desire to avoid such abrupt changes. As a tube user, I am aware of this unfortunate characteristic which is most prevalent in the *VR 105* type. A technical publication last year, by George M. Kirkpatrick, discusses in detail his findings on a batch of tubes concerning this point.

The questionnaire mentioned only the 150-volt tube. The committee has drawn up the hypothetical data on tubes for three voltages, 150, 105, and 75, these being the volt, ages already in use. From the user point of view, these voltages cover a useful range-furthermore, they are spaced so that the starting voltage of the two lower voltage tubes are below the operating voltage of the next higher tube, and so permit operation in tandem, and so further reduce the effect of change of line voltage.

Vinton Ulrich (*Hytron Radio and Electronics Corporation, Salem, Mass.*). Voltage regulator tubes generally have a characteristic which includes a zone of negative resistance. In fact present testing specifications permit acceptance of tubes in which the voltage at 30 milliamperes is less than that at 5 milliamperes. You probably have seen idealized data, representing the voltage regulator tube to have a constant positive resistance characteristic from 5 to 30 milliamperes. The typical voltage regulator tube has a voltage minimum somewhere in the vicinity of 7 to 15 milliamperes, which is the result of a deliberate attempt on the part of the tube manufacturer to produce a tube having the same voltage at 5 and 30 milliamperes.

This characteristic probably can be shifted so that the minimum voltage occurs at or below 5 milliamperes. However, then it is necessary to widen the permissable variations in voltage occuring at 5 and 30 milliamperes. On the basis of JAN testing a wider limit for regulation would be required. But on the other hand, perhaps this wider limit would produce just as acceptable tubes or even more acceptable tubes as the present test procedures completely ignore the presence of a voltage minimum occuring between the 5- and 30-milliampere tests for voltage drop.

The hypothetical specification shows for type *C*(the *OC3/VR105* or *OB2* prototype), a voltage variation characteristic of slightly less than one per cent, and a similar regulation characteristic. The type *OB2* now manufactured by Hytron is a miniature tube having 108 volts drop. Voltage variation between tubes at a given current, is generally within plus or minus $2^1/_2$ per cent although customer acceptance limits are about plus or minus $3^1/_2$ per cent. Customer limits for regulation as per JAN testing is $3^1/_2$ per cent maximum. The average, however, is considerably under 2 per cent. This is also the miniature *OA2*, which has a 150-volt drop and somewhat similar ratings on a percentage basis.

You have heard briefly about the characteristics of voltage regulator tubes, a mention of what is involved in manufacture, and a brief description of what tubes are currently available in miniature.

While currently it is not possible to meet the hypothetical specification, perhaps certain liberalization is possible from an equipment viewpoint. This is where the users can help.

In the interests of reducing tube types, will one or two of the three types suffice? If so, which ones? While we at Hytron lean towards miniature tubes for new production, how important is that size? Is there a genuine preference for a nine pin over the seven pin currently available?

What about replacement of types *OC3* and *OD3* in existing sockets? Or should that matter be ignored on the basis that they are getting by?

ELECTROMETER TUBE

Harry F. Dart (*Westinghouse Electric Corporation, Bloomfield, N. J.*). By definition electrometer tubes are special electron tubes designed for use in the measurement of extremely small currents or voltages. They are among the very earliest tubes designed especially for instrument and industrial use. A resurgence of interest has been created by recent technical developments which have created a necessity for making measurements of current in the order of 10^{-12} ampere and even less.

The survey shows a conclusive unanimity among users that mutual conductance is the most important lifetime characteristic, and they are reasonably generous in asking for a uniformity of plus or minus 15 per cent. A majority voted that the grid cutoff voltage is the characteristic which should be most uniform between tubes and a fairly large permissible variation is acceptable. The tabulation also indicates a preponderance of opinion that the noise level should be improved, and there is a practically unanimous preference for miniature glass envelopes.

As evidenced by the replies, electrometer tubes find their way into a wide variety of adverse operating conditions as indicated by the relatively large number of items listed under the heading of "unusual service operating conditions." These include excessive vibration, high humidity, extreme shock, excessive dirt, high temperature, exposure to chemicals, low temperature, and both high and low pressures. As mentioned under the committee's recommendations, there would appear to be a much larger demand for tubes in this class than is indicated by the totals given at the end of the survey.

As Westinghouse has been in this field for two decades, some of that company's experiences are considered as typical. The nature of the design of the *RH-507*, and most actual applications, are such that the value of the amplification factor is not particularly important. However, an improvement in this characteristic was requested mildly by the survey. Based on the replies to the questionnaire a tabulation of data has been prepared on a new hypothetical electrometer tube.

MISCELLANEOUS TUBES

J. G. Reid, Jr. (*National Bureau of Standards, Washington, D. C.*). The need for improved electron tubes in the instrument field is primarily covered by the ten types already discussed, nine low power vacuum tube types and the gaseous voltage regulator. This is clearly indicated by the results of the AIEE survey of the instrument industry. Conference discussion has emphasized the desirability of concentrating upon development of the types in greatest demand. This is economically expedient, will accelerate the test in service of such tubes, and will permit the most rapid attainment of improved designs and manufacturing procedures.

Nevertheless, a series of "instrument quality" tubes can be of greatest value only when sufficiently inclusive to permit their use *throughout* in most electronic instruments. Some thought should be given to the designation of a second line of development, perhaps more distantly future, covering tube types having functional importance although currently not in the greatest numerical demand. The following tubes are proposed for inclusion in this category. The discussion period which follows will permit the nomination of others.

1. A pentode having high transconductance (5,000 microohms or greater) and low internal capacitance for high frequency use. Although not currently an item of primary demand in instrumentation, this tube is of first importance in the aeronautical field. The improved *6AK5* prototype in the Aeronautical Radio development program should cover this need.

2. A low-mu twin power triode having extremely low plate resistance. This tube would have primary application in current regulation and small motor control applications. A ruggedized, long life version of the *6SA7* might be the answer to this need.

3. A pentode voltage amplifier having the minimum practical heater current. This tube would have primary application in low level input stages, particularly for d-c amplifiers, where heater current is derived from the regulated B supply. In this connection the Signal Corps development of improved alloys for open filament heaters may be of significance.

Although outside the category of low power vacuum tubes, the following types are also important in instrumentation:

1. An improved low power thyratron, having extremely low grid current and high uniformity from tube to tube. This might have primary application in *R-C* timers and in photoelectric controls. The improved *2D21* of the airline program could serve as a basis for this development.

2. Phototubes and photomultipliers having more uniform and constant characteristics.

3. Improved, long life cathode ray tubes and tuning indicators.

It is recognized that improvements in these latter items rest upon progress in the basic physics of emitting surfaces.

Conclusions of the Conference and Proposal of Resolutions

W. R. Clark. It is apparent from the various discussions of this conference that long life and dependability of tubes are the most important factors. Reproducibility of characteristics between tubes is a close second as far as the instrument manufacturers and the industrial users are concerned.

Continuity of supply is vital and notice of withdrawal of the tube ten years before withdrawal takes place would be of valuable assistance to the users.

Discussions have shown—that probably for the time being two lines of tubes will be required. One will be the large industrial type of tube, of which the new red line tubes officially announced by the Radio Corporation of America are a good example. The development of this type of tube is very gratifying to industrial people. However, the survey results show that closer tolerances in some instances are required. There has been no real evidence put forth in the conference that this is not the case. The other type tube would be quite similar in its electrical characteristics to the larger envelope tube, but would be contained in the miniature envelope. The committee understands that development on this line of tubes is under way. This type of tube is of particular importance in the instrument field.

Apparently the instrument manufacturers and the industrial users are not too interested in improved pentagrid converters. However, the interest in the gating tube warrants further consideration by this committee. The committee will be glad to receive any comments that any one might have on what he thinks the tube specifications of th gating tube should be.

It seems that the hypothetical tub presented by this committee, with th modifications just suggested, would be good basis for designs of tubes for the imme diate future for use in instruments and fo other similar industrial purposes.

More distant future objectives of tub manufacturers should be

1. Longer life, 50,000 hours.

2. Closer tolerances.

3. More efficient cathodes which would result in low heater currents.

4. Further reduction in hum, noise, and microphoni is very desirable.

The ultimate in tube design would b reached when tubes will have the dependa bility and as long a life as any other elemen of the circuit. This objective cannot b obtained by a selection of tubes from a lo of regular receiving tubes, but only b complete redesign of the tubes using th best materials available and the latest im proved techniques.

When this exceptionally long life tub has been developed, then the whole circui including the tube, resistors, capacitor and inductances can be built as a replaceabl package unit. This probably would solv the difficulties encountered in some of th industrial fields and eliminate the dirt an corrosion items which trouble those users.

Committee recommendations, as a resul of this conference, are

1. Tube manufacturers and users consider the resul of the survey, plus the discussions of the conference as basis for the design, application, and standardizatio of tubes for instrumentation and similar industri purposes.

2. More complete specifications should be given o industrial tubes. In addition to minimum, average, an maximum tolerance ratings on the important electric characteristics, information should be given on at lea two points on the plate current curve, and preferabl three.

3. Some specifications on change during life should b given. For example, for the amplifier tubes it could b the change in the value of transconductance during li should not exceed ten per cent of its initia value. different specification would be required for other typ of tubes.

4. That instrument people use these new tubes an use them within their ratings.

As for future activities of this committe in this particular field, it is recommende that

1. This committee continue its interest in this work proposed hypothetical tubes, possibly promulgating de sign objectives for additional types of tubes which a needed in the instrument and industrial field.

2. For the present this committee act as a clearin house for information relating to tube specificatio covered in the survey report, and act in close co-ordina tion with JETEC. The committee requests that a those who have definite ideas on more complete specif cations and tolerances than those given in the pr liminary sheets, forward their ideas to this committe care of AIEE headquarters, 33 West 39th Street, Ne York, N. Y.

3. That due to the interest shown in this conferenc another electron tube conference of wider scope b considered for next year.

4. Further discussion with representatives of other us groups should be arranged to discuss common obje tives, avoid duplication of effort, and to reduce th number of special tubes to a minimum.

The proceedings of this conference wi be published. Orders may be placed a AIEE headquarters in New York City.

Completion of Plans Announced for Summer Meeting in Mexico

All is in readiness for the AIEE summer general meeting to be held in Mexico City, June 21–25, 1948. The tentative program announced in *ELECTRICAL ENGINEERING* for May is complete, and many of the papers will present the latest trends and practices in the generation, transmission, and distribution of electric power, as well as its applications to the production of steel, petroleum, mining, textiles, and paper. By virtue of location, a rare opportunity is afforded to spend a vacation in a picturesque and colorful country, and at the same time keep in touch with some of the latest developments in the engineering field.

The summer general meeting committee in Mexico City has taken full advantage of the situation, and extensive plans have been made for sightseeing trips and tours to various places of interest, as well as entertainment each evening.

RECEPTIONS

After the official inauguration of the meeting on Monday morning, a banquet sponsored by the Ministry of National Economy will be held at the Mexico City Country Club. Tuesday noon, there will be an official reception by the mayor and governor of the Federal District to the board of directors and meeting executive committee. On Wednesday evening, a reception will be tended by the Ministry of Hydraulic Resources. Thursday evening will be the President's reception by the Ministry on Foreign Relations. Details of the technical program, inspection trips, and a schedule of events appear in *ELECTRICAL ENGINEERING* for May, pages 487–9.

Native venders as seen from a train in Mexico

GENERAL INFORMATION

Pertinent information pertaining to the meeting has been published in the February, March, April, and May issues of *ELECTRICAL ENGINEERING* in respect to ways to travel, requirements for entering and leaving the country, rate of exchange, hotel accommodations, and restaurants. If you have not already made arrangements to attend the meeting, it is suggested that you should contact the nearest Mexican Consulate and procure a tourist card for the fee of $2.10. Proof of United States citizenship, such as a birth certificate, is required. It also would be worth while in the interest of convenience, when returning, to have a valid up-to-date small pox vaccination certificate.

ADVANCE HOTEL RESERVATIONS

All reservations will be handled by the Mexico Section's local hotel committee, and any individual reservations made directly with the hotels will be referred to the committee for co-ordination. Definite arrangements have been made to concentrate AIEE members and their guests among the following major hotels: Del Prado, Regis, Prince, Reforma, and Geneve. The rates for hotel rooms will range from approximately $5 to $10 for a single room, and from $8 to $14 a day for a double room (in terms of United States dollars). Members should express their preference for single room, double room, or parlor suite, and they should indicate the approximate rate preferred or the limit of desired room rate. Reservations should be made immediately to allow for individual confirmation before setting out to travel to Mexico City.

Revised Consulate List Presented for Mexico Meeting

It has been learned that several of the Mexican consulates listed in the April issue (*EE, Apr '48, p 381*) are but honorary consulates and do not have the power to issue Mexican tourist cards, as was stated. A revised list of Mexican consulates, from which tourist cards are available for the fee of $2.10, upon application either in person or by mail, is as follows:

Arizona—Douglas, Naco, Nogales, Phoenix, Tucson

California—Calexico, Fresno, Los Angeles, San Bernardino, San Diego, San Francisco

Colorado—Denver

District of Columbia—Washington

Illinois—Chicago

Louisiana—New Orleans

Michigan—Detroit

Missouri—Kansas City, St. Louis
New Mexico—Albuquerque
New York—New York
Ohio—Cleveland
Oklahoma—Oklahoma City
Oregon—Portland
Pennsylvania—Philadelphia
Utah—Salt Lake City

It is suggested that when filling out the application for one of the tourist cards, the "purpose" of the trip be stated as "for pleasure and to attend the AIEE summer general meeting in Mexico City."

In addition to the listed consulates, tourist cards also may be obtained at American Airlines' offices or at the border. Proof of citizenship must be presented.

Spokane, Wash., to Play Host to 1948 Pacific General Meeting

The Pacific general meeting will be held in Spokane, Wash., August 24–27, 1948, with headquarters in the well-known Davenport Hotel. Arrangements are being made for a technical program to present a variety of papers on engineering problems and developments in the Pacific Northwest. A number of the inspection trips will be co-ordinated with subject matter on the program. In addition, there will be ample opportunity for sports, trips, and recreation and Spokane, situated within a day's easy motoring of seven national parks, provides an ideal setting to combine attendance with a few days' vacation.

TENTATIVE TECHNICAL PROGRAM

Many of the problems will deal with the problems of high voltage, long distance power transmission, corona, carrier current for telemetering and load control, fault location and insulation, and the operation of the Northwest power pool. Other papers will treat the subjects of hydraulic power generation, bussing arrangement and 230-kv switchyards at Grand Coulee, radio telephone service, and radio-frequency heating which will be discussed in a combined communication and industrial session, and still another industrial session will present a variety of papers on electric applications in the mining, lumber, and paper industries.

INSPECTION TRIPS

Among the inspection trips in prospect are a visit to the large aluminum reduction plant of the Permanente Metals Company at Mead, and nearby Bonneville Power Administration 220–115–138-kv 500,000-kva substation. A trip also is planned to the Trentwood aluminum rolling mill, which is one of the largest aluminum rolling mills in the world and the most recently built. This plant has some 250,000 horsepower and connected load including 75,000 kw of electric heating furnaces. The operations from the casting of the slides on through the rolling and processing of aluminum from the bar to the finished sheets may be seen.

Arrangements are being made for an all-day trip to Grand Coulee Dam and the hydroelectric plant with its ultimate capacity of $2^1/_2$ million horsepower. After a trip through the plant, a short lecture on the installation will be given.

Arrangements also are being made for a trip to the Bunker Hill and Sullivan Mining and Concentrating Company at Kellogg, Idaho. This is the largest lead silver mine in the world and visitors will have an opportunity to see the electrolytic zinc plant, smelting and mining operations, and the 13,000-volt underground distribution system described in one of the technical papers.

SOCIAL EVENTS

On the first evening of the meeting, there will be an informal dance and reception to the president. The annual banquet and entertainment will be held on Thursday evening.

In addition to the foregoing events, special entertainment has been arranged for the women during the various afternoons and evenings in the form of golf, teas, a bridge, and trips. The women are invited to take any of the inspection trips previously mentioned.

One afternoon will be for golfers, with opportunity to compete for the John B. Fisher trophy which is awarded annually to the winner of the tournament.

GENERAL MEETING COMMITTEE

Members of the committee making arrangements are as follows:

Richard McKay, *chairman;* H. C. Glaze, Jr., *vice-chairman;* H. Jack Reeves, *secretary;* T. Wendall MacLean, *treasurer;* W. H. Blankmeyer; J. L. Buckley; D. I. Cone; M. D. Duffy; H. M. Gustafson; D. R. Hoopes; G. E. Jenner; C. A. Poppino; W. C. Smith; H. D. Strong; C. F. Terrell

The chairmen of subcommittees are:

H. B. Hodgins, *program;* N. H. Meyers, *hotel and registration;* Glenn George, *transportation and trips;* H. L. Vincent, *entertainment;* W. L. Thrailkill, *golf;* R. D. Sloan, *student activities;* Hugh B. Tinling, *publicity;* W. W. Watkins, *finance;* Mrs. L. R. Gamble, *ladies' entertainment*

Technical Committees Plan Nine Conference Meetings

Because of the outstanding success of the AIEE conference on electron tubes held in Philadelphia, Pa., March 29–30, 1948 (*EE, May '48 pp 494–97*) and the AIEE conference on rubber and plastics (*EE, June '48, pp 603–05*) several AIEE technical committees are planning conferences for 1948–49 on various subjects. A description of this new type of AIEE meeting was given in a previous issue of *ELECTRICAL ENGINEERING* (*EE, Feb '48 page 189*). So far nine conferences are being planned.

A 2-day conference on electronic aids to medicine, sponsored by the subcommittee of the same name under the AIEE electronics committee, will be held in New York, N. Y. November 8–9, 1948. Doctor W. A. Geohegan, Cornell Medical College, New York, N. Y., chairman of the sponsoring subcommittee has announced that the subjects to be covered include

Biological requirements in amplifiers
Present practice in biological amplifier design
Biological requirements in recording devices including cathode-ray oscillograph, electrocardiograph, and the electroencephalograph
Present practice in biological recorder design
Biological requirements on instruments for radioactivity measurements
Health and protection instrumentation
Biological requirements in instruments for stable isotope measurements
Present practice in biological stable isotope instrumentation

This is the first major activity of the AIEE to bring the physicians' problems to the attention of the engineer who designs his diagnostic and therapeutic devices.

A one-day conference on electric welding is contemplated by the AIEE electric welding committee to be held in Detroit, Mich. early in November 1948. This conference will include problems of both arc and resistance welding with power supply for welding as one of the more important topics of discussion.

Two one-day conferences on problems in the textile industry are being planned by the AIEE subcommittee on the textile industry. This subcommittee reports to the genera industry applications technical committe under L. A. Umansky of the General Electri Company, Schenectady, N. Y., as chairman One of these conferences will be held i Boston, Mass., to accommodate the Nev England and Canadian textile mills and th other is being planned for Atlanta, Ga., fo the southern mills.

A materials handling conference has bee suggested for Chicago, Ill. So far the dat for this conference has not been set but it wi be announced in *ELECTRICAL ENGINEERING* as soon as possible. This subject is particularly apt one for the Chicago area where millions of tons of ore are handled eac year, and should excite a great deal of interes

AIEE PROCEEDINGS

Order forms for AIEE *PROCEEDINGS*, and abstract of the papers included, have been published in *ELECTRICAL ENGINEERING* as listed below. Each sectio of *PROCEEDINGS* contains the full, formal text of technical paper including discussion if any, as it wil appear in the annual volume of *TRANSACTIONS* *PROCEEDINGS* are issued in accordance with th revised publication policy that became effective Januar 1947 (*EE, Dec '46, pp 576–8; Jan '47, pp 82–3*), and ar available to AIEE Associates, Members, and Fellows.

Meetings	Abstracts	PROCEEDINGS Order Forms
Winter	Jan '47, pp 84–93; Feb '47, pp 190–1	Feb '47, pp 33A and 34A
North Eastern District	Apr '47, pp 401–02	June '47, pp 55A and 56A
Summer General	June '47, pp 607–14; July '47, p 708	
Pacific General	Aug '47, pp 840–2	Dec '47, pp 55A and 56A
Middle Eastern District	Sept '47, pp 925–7	
Midwest General	Nov '47, pp 1125–8	
Winter ('48)	Jan '48, pp 76–87	Apr '48, pp 49A and 50A

It will be sponsored by the subcommittee on materials handling, under E. M. Hayes of the Dravo Corporation, Pittsburgh, Pa., as chairman.

A conference on instrumentation in nucleonics is being planned by the nucleonics committee under Doctor J. J. Smith of the General Electric Company, Schenectady, N. Y., chairman. This conference will be sponsored jointly by AIEE, the Institute of Radio Engineers, and the Argonne Laboratories, Oak Ridge, Tenn., the center of the Atomic Energy Commission's instrumentation activities, will be asked to participate, as well as Brookhaven National Laboratory at Upton, N. Y., and *Nucleonics* magazine. The AIEE nucleonics committee was organized a year ago and is represented on the joint subcommittee on nucleonic instruments jointly with the instruments and measurements committee. Tentative arrangements are to have the conference in New York City in the Fall of 1948.

The instruments and measurements committee, with E. I. Green of Bell Telephone Laboratories, New York, N. Y., as chairman, is considering a conference on high-frequency measurements. Washington, D. C., has been suggested as a locale for this one-day meeting and the National Bureau of Standards and the Institute of Radio Engineers have indicated a desire to be joint sponsors.

The electron tube conference, so successful this year, will be repeated next year in March. The higher-capacity control tubes and power supply tubes will be included in the types to be discussed. The objectives of the conference will be to outline the limitations of tubes and to discuss suggested improved characteristics. The joint subcommittee on electronic instruments will be joined by the electronic control subcommittee of the industrial control committee, and the subcommittee on electron tubes of the electronics committee in sponsoring this conference.

The conference on rubber and plastics will be repeated in Akron, Ohio, in March of 1949.

Outstanding features of these conference-type meetings include the following:

1. They highlight one subject only and are one to two days in length.

2. Extreme informality with extended opportunity for discussion is the rule rather than the exception of these gatherings.

3. The locale is selected with the conveniences of the engineers engaged in the particular field kept in mind. Hence, Akron is indicated for rubber, and Boston and Atlanta for textiles.

4. Proceedings of the conference, including all papers and the discussion, are made available in a single pamphlet.

Further information about these conferences may be obtained by writing to C. C. Wilson at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Rubber and Plastics Industries Discussed at Second AIEE Conference

Some 134 people, including representatives of many rubber and plastics manufacturing companies as well as equipment manufacturers, attended the AIEE conference on electrical engineering problems in the rubber and plastics industries which was held in the auditorium of the M. O'Neil Company's department store in Akron, Ohio, April 20, 1948. This was the second of a new type of AIEE national meeting known as the AIEE conference planned to provide a means for specialists in a particular field to get together and discuss mutual problems (*EE, Feb' 48, p 189*).

This conference was sponsored by the AIEE subcommittee on rubber and plastics industries and the Akron Section acted as host to the meeting. Characterized by a group of seven interesting papers and a lively and spirited discussion, the conference was one of an exploratory nature which brought out a few interesting topics for future meetings of this type.

The conference was opened by K. W. John, United States Rubber Company, Detroit, Mich., and chairman of the subcommittee on rubber and plastics industries, who welcomed the members and the guests present. Additional introductory remarks were offered by L. A. Umansky, General Electric Company, Schenectady, N. Y., who is chairman of the AIEE committee on general industry applications of which the rubber and plastics industries group is a subcommittee. He pointed out the large use of electric power in the rubber and plastics industries. He also indicated the great similarity between electrical problems that arise in the steel and the textile industries and the rubber and plastics industries.

DISTRIBUTION SYSTEMS

The morning technical program comprised three papers the first of which was "Electrical Power Systems for Small Rubber Plants," by B. D. Morgan, of the Johnson and Johnson Company, New Brunswick, N. J.; R. S. Ferguson, of the Goodyear Tire and Rubber Company, Akron, Ohio; and H. J. Finison, of the General Electric Company, Schenectady, N. Y. The paper was presented in two parts. B. D. Morgan pointed out that the electric power distribution problem in three small plants, a vinyl sheeting plant, an adhesive plaster plant, and a small rubber tire plant, were basically the same. It was possible to make a general study of these plants and arrive at some basic conclusions which could be applied by anyone recommending electric power equipment for plants of this type. He outlined the similarities in these plants and the problems that would arise in these considerations.

H. J. Finison discussed the selection of voltage for the small plant. He pointed out that the selection of voltage would have a bearing on the cost of motors and controls; voltage dips; it would determine short-circuit currents which, in turn, would affect the cost of protective equipment such as circuit breakers; availability of replacement equipment; cable costs; and supply voltage available. He showed a diagram of a power distribution system embodying these considerations.

A prepared discussion on this paper was presented by Walter Stern, United States Rubber Company, Detroit, Mich. He pointed out that the data in the paper were quite complete and very useful. He also cited a number of problems in a small plant in Chicago and how the solutions arrived at there closely corroborated those of the authors. Following this presentation the meeting was thrown open to a discussion.

SPOT CONVERSION

The second of the morning papers was called "Spot Conversion for Adjustable Speed Drives in Rubber and Plastics Manufacturing Plants," by C. E. Robinson, Reliance Electric and Engineering Company, Cleveland, Ohio. "Spot conversion" was defined as a device or system for securing the advantages in flexibility of adjustable voltage d-c power at various locations in a plant where the electric distribution system utilizes the advantages of alternating current. Various methods of speed-range control were covered and the advantages of spot conversion equipment versus a d-c supply were cited.

A prepared discussion on this paper was presented by J. Grotzinger of the Goodyear Tire and Rubber Company, Akron, Ohio. He cited a number of applications of spot conversion equipment in his company. He also asked if Mr. Robinson's company had made any studies showing the relative costs of the two systems for a particular case. Mr. Robinson replied that the information is

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Future AIEE Meetings

Summer General Meeting
Teachers College, Mexico City, Mexico
June 21–25, 1948
(Final date for submitting papers—closed)

Pacific General Meeting
Spokane, Wash.
August 24–27, 1948
(Final date for submitting papers—June 10)

Middle Eastern District Meeting
Hotel Statler, Washington, D. C.
October 5–7, 1948
(Final date for submitting papers—July 21)

Midwest General Meeting
Schroeder Hotel, Milwaukee, Wis.
October 18–22, 1948
(Final date for submitting papers—August 3)

Southern District Meeting
Birmingham, Ala.
November 3–5, 1948
(Final date for submitting papers—August 20)

AIEE Conference on Electronic Aids to Medicine
New York, N. Y.
November 8–9, 1948

Winter General Meeting
Pennsylvania Hotel, New York, N. Y.
January 31–February 4, 1949

Southwestern District Meeting
Dallas, Tex.
April 20–22, 1949

Summer General Meeting
New Ocean House
Swampscott, Mass.
June 20–24, 1949

available from his company and that it demonstrates the economic advantages of spot conversion equipment.

An open discussion followed the prepared discussion. It was brought out that a war-time development, the tire testing dynamometer for testing tires at high speed, used spot conversion equipment to get proper acceleration of the tire. Spot conversion equipment is becoming more and more popular in other industries such as the machine tool industry and the steel processing industry.

EQUIPMENT ROOMS

Following a short intermission, F. A. Green, of the B. F. Goodrich Company, Akron, presented a paper called "Separate Electric Equipment Rooms Versus NEMA Enclosures for Protection of Motors and Controls." NEMA (National Electrical Manufacturers Association) enclosures for electric equipment were discussed and slides were shown of the various types of motors and associated equipment in enclosures. The various advantages and disadvantages of separate equipment rooms then were taken up. The paper concluded with recommendations that totally enclosed motors be considered for all general purpose applications; that location of large motors in equipment rooms would permit the use of least expensive motors and result in minimum maintenance; and that separate ventilation should be provided for large motors in production areas. On the basis of cost and maintenance, it was recommended that controls for hazardous processes be located in a separate room.

R. F. Snyder, of the Goodyear Tire and Rubber Company, presented a prepared discussion in which he pointed out that the air in rubber and plastics plants is very bad on electrical insulation. He endorsed totally enclosed motors for application in these types of plants.

During the open discussion an experience was cited where an engineer had an enclosure built around a motor thus solving his insulation corrosion problem. This brought up the question of whether it is better to build a housing around the motor or to buy totally enclosed motors, having large size motors in mind. The adverse effects of grease under certain conditions on motors also was cited. Mention was made of an installation using open-type motors that had been running for a number of years with little or no trouble with regard to insulation breakdown. This was corroborated by Chairman K. John who said that his company (The United States Rubber Company) also has open-type motors on banbury drives that have been run for years with no trouble at all. Another point of interest that was brought out as a possible explanation was the fact that a furnace-type black is much more prevalent in rubber plant atmospheres than channel black is today as compared with years ago. The furnace-type black is more conducting than channel-type black and consequently affects insulation to a greater degree. Plastics plants need special protection from the corrosive effects of plasticizers.

It was pointed out that if operating conditions can be anticipated, motor manufacturers can do a better job of protection against corrosive atmospheres than plant operating personnel by building enclosures. Control rooms seem to be the trend, especially in high-voltage control systems. The suggestion was made recommending separating controls in the control equipment room so that the failure of one control will not affect others. It also was mentioned that space for control rooms is hard to find in an existing plant. This seems to be a perennial battle with planning engineers—finding space for such items as control equipment rooms. It was pointed out that space is not being wasted by putting equipment in a control room rather than beside the motors in the operating section of the plant. A number of people discussed the problems associated with the temperature control of air for control rooms. It was pointed out that Canadian practice is to use enclosed controls and to place them as near to the motors as possible.

LUNCHEON HELD

The conference then was adjourned for the morning. A luncheon which was attended by about 110 people was held in a private dining room in the department store. No talks were presented during the luncheon.

ELECTRIC BRAKING

The program after lunch included four papers, the first of which was "Electric Braking for Rubber Mills and Calendars," by B. J. Dalton, General Electric Company, Schenectady, N. Y. This paper covered various braking schemes for quick stopping of rubber mills and calendars. A method of calculating roll travel during stoppage of rubber mills and calendars also was presented. It was pointed out that in most instances the energy stored in the machinery driven is small compared with that stored in the rotor of the driving motor. Thus stopping the system becomes primarily a problem of stopping the motor.

A prepared discussion was presented by V. O. Johnson of the United States Rubber Company. Mr. Dalton's paper had mentioned a means of calculating the value of the braking resistance necessary to obtain minimum stopping revolutions of a motor. In his discussion Mr. Johnson pointed out that his experience indicates that optimum braking resistance could be varied over a range of two to one and still produce satisfactory stoppage. He also pointed out that with high-speed calendaring operations the WK^2 (radius of gyration) effect of the driven equipment becomes important with regard to stopping.

During the open discussion that followed, a number of persons mentioned that their companies were using d-c dynamic braking systems successfully in their plants. Mr. Ferguson of the Goodyear Tire and Rubber Company (coauthor of the first paper presented in the conference) showed a number of slides indicating quantitative data on motor stoppage.

RUBBER MACHINERY DRIVES

The second paper in the afternoon session was "Electric Drive Characteristics for Rubber Machinery," which was presented by A. T. Bachelor of the Westinghouse Electric Corporation, East Pittsburgh, Pa. He pointed out that the rubber industry is in an advance stage of electrification of machinery. Nearly all rubber machinery now is driven individually or in groups by electric motors. Electric drives have the advantages of flexi-

Milwaukee—Midwest Meeting Site

Lincoln Memorial Drive with yacht basin in background looking northeast from Wisconsin Avenue, the heart of Milwaukee, Wis., host city for the 1948 Midwest general meeting, October 18–22

bility, high efficiency, and freedom from most of the hazards of mechanical drive equipment.

W. J. Secrest of the Firestone Tire and Rubber Company presented a prepared discussion on this paper. He prefers wound rotor motors for plasticator applications. He believes that the current limiting fuse is one of the greatest contributions to safety in industrial plants. It also was mentioned that where furnace-black atmospheric conditions prevail, motors are enclosed and ventilated in his company.

TWO CONTROL PAPERS

The last two papers presented during the conference were concerned with problems of measurement and controls in rubber and plastics plants. The first of these was "The Measurement and Control of Tension and Its Relation to Motor Input," by H. L. Smith of the General Electric Company, New York, N. Y. This paper discussed how electrical input on d-c motors is related to the motor torque and to the fabric tension, and how these can be calculated from a few simple measurements.

O. M. Bundy of the Clark Controller Company, Cleveland, Ohio, presented a prepared discussion on this paper. He pointed out that fabrics, mechanical equipment, and transients all have a marked effect on tension control by motors. Variation in fabrics, and variations in stretch, make measurements very difficult. It also was pointed out that mechanical linkages in tension measuring equipment have a very important effect upon accuracy of control.

The second paper on controls and the last paper of the conference was "Temperature Measurement and Control on the Electrically-Heated Molding Processes for Rubber and Plastics," by F. L. Spangler of the Leeds and Northrup Company, Philadelphia, Pa. This paper dealt with temperature measurement and control of processes using resistance heating. Various molding processes in which resistance heating has been applied were described and the temperature control systems were discussed.

A prepared discussion on this paper was presented by H. S. Mika of the United States Rubber Company. He offered the suggestion that more instrumentation papers be presented at these types of meetings. He questioned the feasibility of controlling die temperatures to plus or minus one-half of a degree. He also brought out the difficult problem of speed of response of the control systems when used in short-time molding cycles. Mr. Spangler pointed out that for the speed of response desired it was necessary to select carefully the primary element of the control system. He also indicated that modern resistance thermometers are being made with speeds of response as good as those of small thermocouples.

SUBCOMMITTEE MEETING

After the conference was over the AIEE subcommittee on rubber and plastics industries held a meeting to discuss the conference and future plans. That the conference was a success was evidenced by the interest and enthusiasm of the audience and the large attendance at the conference. Accordingly Mr. Umansky suggested that the subcommittee plan one such conference per year. He recommended that it be held in Akron as it was an ideal spot for a meeting concerning itself with rubber and plastics industries. The subcommittee agreed that this was a good idea and planned to hold next year's conference sometime in March. As soon as details are available they will be published in *ELECTRICAL ENGINEERING.*

PUBLICATION OF CONFERENCE DATA

As in the case of the conference on electron tubes the "Proceedings of the Conference on Electrical Engineering Problems in the Rubber and Plastics Industries," is to be published. Included in this publication will be the full text of the papers, the prepared discussions, and any other discussions that originated from the floor during the conference. This publication will be available from the AIEE Order Department, 33 West 39th Street, New York 18, N. Y. at $3 per copy ($1.50 to AIEE members). About 80 advance orders were taken for the Proceedings at the conference. Members and others desiring copies of this publication are urged to send in their orders and remittances as soon as possible so that an accurate estimate of the demand can be made which will insure publication of sufficient quantities.

Brief digests of the seven papers presented at the conference are scheduled for publication in the next issue of *ELECTRICAL ENGINEERING.*

Analysis of Registration at Akron, Ohio

District	Members	Men Guests	Total
1	6	2	8
2*	40	59	99
3	6	0	6
4	1	0	1
5	7	6	13
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	2	5	7
Totals	62	72	134

* District in which conference was held.

North Eastern District Meets in New Haven, Conn.

With the Connecticut Section acting as host, the 24th in the series of North Eastern District meetings was held at the Taft Hotel, New Haven, Conn., April 28–30, 1948. This was the third such meeting to be held in New Haven (previous meetings were held there in 1928 and 1936). A heavy program presenting a wide range of topics catering to diversified interests, drew a verified registered attendance of 669. An analysis of this attendance, and comparison with previous years, are presented in accompanying tabulations.

TECHNICAL PROGRAM

The technical program was organized into 11 technical sessions and three Student technical sessions, running an average of about three in parallel, both mornings and afternoons, during a $2^{1}/_{2}$-day period. On Friday morning, there were two technical sessions and three Student sessions operating in parallel. A total of 71 technical topics was accommodated on the schedules of the sessions, including 18 regular technical program papers, 32 District papers, and 21 Student papers. The industry applications conference session accommodating the informal presentation and discussion of six district papers relating to textile machinery and textile mill problems drew a sustained attendance of about 100 persons and proved to be the most popular of the various technical sessions.

In keeping with a recently inaugurated further step in the development of the new AIEE publication program initiated in January 1947, all the regular technical program papers will be digested in *ELECTRICAL ENGINEERING*, appearing for the most part as 1-page articles, each one presenting in concise form the essential substance of the basic paper. Of the 18 current North Eastern District technical program papers, seven were published in the May issue, six will be found listed among the table of contents of this issue, and the remaining five will be scheduled for publication as soon as they are received from the authors. In due course, the full texts of these 18 basic papers and their associated discussion, if any, will be available for selective distribution to the AIEE membership in accordance with currently established procedure, and will be listed along with summer general meeting papers in a *PROCEEDINGS* order form scheduled to be published in the August issue of *ELECTRICAL ENGINEERING* advertising section. As a further step in current efforts to carry the substance of AIEE District and general meetings, and technical conferences, to the general membership, a composite group of digests of the 32 District papers on the New Haven meeting program, prepared with the collaboration of the various authors, is scheduled for publication in the forthcoming July issue of *ELECTRICAL ENGINEERING.*

STUDENT PROGRAM

The 21 Student technical papers previously referred to included 7 from the Student Branch at Worcester Polytechnic Institute, 3 from the Student Branch at Cornell University, 2 from the Student Branch at Massachusetts Institute of Technology, 3 from the Student Branch at the University of Connecticut, and 6 from the Student Branch at Yale University. These papers were presented Friday morning April 30 in three parallel sessions in accordance with the following listing:

Session A

Edmund J. Drenzek, presiding

(*First prize*) **Multiplexing of Audio Channels by Time Division.** *George Arthur*, Yale University

Phase Measurements by Pulse Techniques. *Robert M. Lerner*, Worcester Polytechnic Institute

Increasing the Natural Resonant Frequency of Electromechanical Oscillating Systems. *George Gamble*, University of Connecticut

Synthesis of Stagger Tuned Intermediate-Frequency Amplifiers. *Samuel E. Church*, Yale University

Testing Methods for Transients in Audio Amplifiers. *Thomas R. Hodge*, Yale University

A Proposed Color Television System. *Jesse H. Haines*, Massachusetts Institute of Technology

Session B

Richard R. Shank, presiding

(*First prize*) **Properties and Applications of Selenium Rectifiers.** *A. L. Odmark*, Yale University

A Simplified Gaussmeter for Measurement of Steady Magnetic Fields. *James Biggerstaff*, University of Connecticut

Electrical Engineering Education. *Edward S. Rosett*, University of Connecticut

A Transient Oscilloscope. *Peter M. Shultheiss*, *Richard R. Shank*, Yale University

The Theory of the Polyphase Commutator-Type Speed Regulator. *R. S. Sanford*, *E. O. Spencer*, Yale University

Automatic Frequency Control System for 75 Kv Alternator. *Owen W. Kennedy*, Worcester Polytechnic Institute

A Single-Phase Linear Motor. *R. C. Cornelison*, Cornell University

Session C

John A. Tucker, presiding

(*First prize*) **A New Approach to Electronic Musical Instruments.** *Alan Pearlman*, Worcester Polytechnic Institute

Automatic Combustion Control. *Frank Holby*, Worcester Polytechnic Institute

Fundamentals of Amplidyne Control. *R. G. Winklepleck*, *M. Cohen*, Cornell University

Operational Characteristics of D-C Motors on Rectified Alternating Current. *Alton S. Kelsey*, *William L. Wagner*, Worcester Polytechnic Institute

Operational Analysis. *M. Rosenblatt*, Cornell University

The Art of Creation. *Robert E. Mueller*, Massachusetts Institute of Technology

GENERAL SESSION

With Vice-President Ernest W. Davis presiding, all of Thursday morning was given over to a general session featuring President Blake D. Hull, and T. J. Ruffell and C. W. Mayott of the Connecticut Section.

President Hull spoke informally of AIEE administrative affairs and operating problems. He pointed out that as of the close of the current fiscal year April 30, AIEE with its 28,256 members and some 12,000 Student Members is the largest engineering organization in the world, a situation which brings with it important organizational obligations and opportunities with reference to the engineering profession in general, as well as setting up the requirement for internal administrative and organizational adjustments to provide and preserve a necessary flexibility of operation. President Hull mentioned the initial success of the new technical committee organization, which he described as holding much promise of meeting the challenges of current growth and expansion in the electrical field. The present 31 technical committees meet current technical requirements, and the flexibility of the 4-group technical organization of the Institute will facilitate the formation of new committees as required in new technical fields.

President Hull mentioned the present-day AIEE membership as being made up of approximately 4 per cent Fellows, 28 per cent Members, 26 per cent six-year Associates, and 42 per cent as Associates of less than six years standing. In addition to the technical and administrative organization, AIEE currently is functioning in the field through 81 Sections, 36 Subsections, numerous technical groups, and 126 Student Branches.

Mr. Hull pointed out quite frankly that the rapid growth in Institute membership and in the scope of District and national meetings, local Section activities, and other activities have brought forth problems of considerable magnitude in the field of AIEE publication services, as well as in AIEE finances. He pointed out that in spite of inflation and the resulting reduction in purchasing power of AIEE dues-dollars and a greatly expanded scope of organizational activities, AIEE still is operating on the old and long established schedule of membership dues. Mr. Hull mentioned some of the features of the new publication program worked out between the publication committee and the board of directors, and pointed out that other and related problems not only were receiving the continued attention of the publication committee and the board of directors, but that financial matters were being studied separately by a committee of the board of directors and by a special committee appointed by the Sections committee at the recent general meeting in Pittsburgh, the latter committee devoting especial attention to the matter of Section finances in relation to Section activities.

President Hull emphasized again that AIEE is a wholly voluntary organization made up of individual members, and that it is the members themselves who must make of the organization whatever they wish it to be. He mentioned briefly the Institute's 64-year heritage of professional standing and leadership, and expressed confidence that the membership would meet successfully the challenge of both organizational and national problems arising in the aftermath of World War II.

Thomas J. Russell, chairman of the Connecticut Technical Council, addressed the general session on "Conservation of Our Nation's Natural Resources." Stating that "science is not 'limitless' and we cannot afford to be lulled to sleep by such platform platitudes," Mr. Russell urged with convincing emphasis that "our republic cannot survive unless we as individuals and engineers do something to stem or offset the continuing devastating dissipation of the raw materials that have made the United States a world power." It is planned that the substance of Mr. Russell's address will be published in an early issue of *ELECTRICAL ENGINEERING.*

Preliminary to his address, Mr. Russell responded to President Hull's current effort to bring about the formation in the engineering profession of an appropriate agency for joint action on matters of common concern to the various technical branches of the profession. Mr. Russell stated that the Connecticut Technical Council, in recent discussions of the proposals set forth in Mr. Hull's article in the April issue of *ELECTRICAL ENGINEERING*, had taken action urging "the formation of a joint organization based upon the officers or executive committees of the several individual engineering organizations rather than the formation of another organization of individual engineers." Mr. Russell urged as one major objective of such a joint organization, the maintenance in Washington of a competent liaison representative "to be on the alert at all times for any and all legislations affecting engineers or engineering, or on which engineering advice and guidance would be desirable in the public interest."

C. W. Mayott of the Hartford Electric Light Company discussed "Electric Power Supply of the United States, With Special Emphasis on the North East," in which he elaborated upon the general substance of his article as published in the February 1947 issue of *ELECTRICAL ENGINEERING*, with some special and detailed attention to the New England states. Mr. Mayott said "Since the war, our industrial expansion has been beyond that ever experienced on this globe. This has materially reduced our margins of reserves in all materials, among which is our electric power supply. It is quite natural under these conditions for people to be concerned as to just how serious the situation is and what is being done about it. Many articles which purport to state the situation are being written, and, for one reason or another, most of these articles are distorted. We have such scare headlines as appeared in *Colliers* February 28, 1948, under the heading "Our Lights Are Going Out" by A. G. Mezerik. As Al Smith used to say, 'Let us look at the record.'

> . . . The reserve capacity for the United States at the time of the December 1947 peak was approximately five per cent. For most of the load this was the maximum peak. Careful check . . . shows a curtailment during this peak period of 98,000 kw in uninterruptable power and 48,500 kw in other power. Also a reduction in load affected by voltage reductions amounting to about 75,000 kw. The maximum voltage reduction report was five per cent. This was for a load of 50,000,000 kw.
>
> Possibly the most adverse publicity was caused by the cutting off of interruptible power to a chemical company in California. This company had been on the schedule for a number of years paying a very reduced rate for its power on the basis that the power company could cut the power off whenever water conditions seemed to warrant such action. This chemical company was selling chlorine to the city of Los Angeles, which was using it to sterilize its sewage so that the beaches along that section of the California coast could be used. When the interruptible power was discontinued, the chemical company stopped shipment of chlorine to the city of Los Angeles. That section of California coast was then declared unsafe for bathing."

This apparently prompted Mr. Mezerik's imaginative article.

Mr. Mayott reported further that although

> domestic and commercial has doubled in the past eight years, electric service has reached an extremely high standard of continuity, frequency, and voltage. The year 1947 was the most critical year for the power industry throughout the country. This was aggravated by low hydroelectric output in many areas. These critical water conditions continue in California and some other sections. Electrical manufacturers just cannot produce the equipment for us at a faster rate than they are doing. Turbines, boilers, and so forth, being ordered now cannot be delivered before late 1951 or '52. Our average margin of reserve was close to five per cent for the peak of 1947, but will be about eight per cent for 1948 and will increase materially the following years. There was some reduction in the standard of service in some areas in 1947. There were some cases where industrial load (particularly so-called interruptible load) was curtailed at times. There will be some in 1948, but the percentage should be very small. The power margins were low, but the margins in other commodities were smaller. . . . Except for catastrophe, your lights are not going out.

The substance of Mr. Mayott's address is expected to be published in an early issue of *ELECTRICAL ENGINEERING.*

INSPECTION TRIPS

The program of inspection trips was so arranged that some were available each day of the meeting. Where the nature of the inspection trip was related to some of the papers on the program, the trips were scheduled immediately following such technical sessions. These trips included the following. The plant of the J. B. T. Instruments, Inc., where the manufacture and testing of various precision electrical and temperature measuring instruments were observed. The assembly and testing of various electric appliances and electric toys including miniature railroad trains were viewed at the plant of the A. C. Gilbert Company. The New York, New Haven, and Hartford Railroad made available at a convenient siding one of their newest all electric locomotives, also one of their newest Diesel-electric locomotives; also arranged an inspection trip of the 10,000 reactive kilovolt amperes shunt capacitor installation which has been effective in improving the voltage regulation at the New Haven end of the New York-New Haven electrification of the 4-track system. This shunt capacitor bank on the 22-kv railway transmission line is the first such installation to be made on a 25-cycle single-phase system. The installation previously was described in AIEE technical paper 48-39 "Shunt Capacitor Installation for Single-Phase Railway Service," by H. F. Brown and R. L. Witzke, presented during the winter general meeting at Pittsburgh.

The reversed-cycle heat-pump heating and cooling system used by the United Illuminating Company to heat and cool its New Haven general office building was inspected incidental to the Friday session on special industrial applications and heating. Inspection groups also were accommodated by the Dunham laboratory (electrical engineering) of Yale University, the Bridgeport plant of the wire and cable division of the General Electric Company, the New Haven manufacturing plants of the Winchester Repeating Arms Company and the Rockbestos Products Company, and a local steam electric generating plant of the United Illuminating Company where a principal point of interest was a new 30,000-kw unit now being installed.

ENTERTAINMENT

Principal feature of the entertainment program was an informal banquet Thursday evening, April 29, in the ballroom of the Taft Hotel, the meeting headquarters. The banquet was presided over by J. F. Walker of the Connecticut Section, as general chairman of the North Eastern District committee. Professor A. G. Conrad of the electrical engineering department at Yale University proved himself to be an adept and spirited master of ceremonies as he ran the show which included informal remarks from President Hull, Vice-President E. W. Davis, and Secretary H. H. Henline, and an accomplished demonstration of prestidigitation put on as an avocational sideline by Latham Lambert commercial manager for the Southern New England Telephone Company, New Haven. The feature take-off of the evening, which brought down the house, was the presentation by Master of Ceremonies Conrad on behalf of the Connecticut Section of a complicated Rube Goldberg-ish "regretatron" to Past Section Chairman H. F. Brown "in commemoration of his breaking of the long technical silence of the Connecticut Section by writing two AIEE *TRANSACTIONS* papers during the past year." The contraption, consisting of bottles, wires, rods, vacuum tubes, and finished off with a kitchen funnel, was described as "capable of filtering out all statements which a platform speaker might subsequently regret."

A liberal program of entertainment for the women guests kept the women busy each of the three days of the meeting. The program included a luncheon at the faculty club and a tour of the Yale campus, Wednesday; luncheon at the Sanford Barn and trip through the Peabody Museum of Yale University and the New Haven Colony Historical Society, Thursday; and a trip to the General Electric Company's Consumers Institute at Bridgeport, Friday, with luncheon served by the General Electric Company in the Blue Room of its Bridgeport plant.

PRIZES AWARDED

District prizes for 1946–7, the last of the North Eastern District prize awards to be made under the now superseded AIEE paper prize program, were awarded at the banquet by District Secretary Victor Siegfried as follows:

1. To F. S. Rothe and Charles Concordia, for their 1947 North Eastern District meeting technical program paper "Transient Characteristics of Current Transformers During Faults," the 1947 prize for the best technical paper from the North Eastern District.
2. To Thomas M. McCaw for his District paper presented informally at the North Eastern District meeting in 1947, "A Photoelectric Color-Temperature and Exposure Meter," the 1947 District prize for the best initial paper.
3. To Ralph O. Williams, then a student at Northeastern University, for his paper "Electronic Fractional Horsepower Torque Measuring Indicators," the North Eastern District prize for best undergraduate student paper for 1946–7.
4. To W. J. Dornhoefer and G. C. Bill, then of Yale University, for their paper "The Application of Circle Loci in the Solution of Electrical Problems," the District prize for the best graduate student paper for the year 1946–47.

The 19 student papers listed elsewhere on these pages were presented in three parallel student sessions Friday morning April 30. Because of the large number of papers involved, and the necessity of running three parallel sessions to accommodate them, the District executive committee decided to make one first prize available for each of the three parallel sessions. These were won by the following students:

1. George Arthur of Yale University for his paper "Multiplexing of Audio Channels by Time Division."
2. A. L. Otmark of Yale University, for his paper "Properties and Applications of Selenium Rectifiers."
3. To Alan Pearlman of Worcester Polytechnic Institute for his paper, "A New Approach to Electronic Musical Instruments."

These 1948 student District prizes were awarded by District Secretary Siegfried at a joint student session held immediately following the three student technical sessions. This student general session was presided over by Dean E. R. McKee of the University of Vermont, chairman of the student activities committee of the North Eastern District. President Hull, Secretary Henline, and Presidential Candidate E. S. Lee each spoke briefly, covering various phases of professional and AIEE activities as relating to electrical engineering students.

COMMITTEES

Credit for the organization and operation of the North Eastern District meeting in New Haven goes to the following committee personnel:

District Meeting Committee

J. F. Walker, general chairman; E. W. Davis, vice-president, North Eastern District; Victor Siegfried, secretary, North Eastern District; E. R. McKee, chairman, Student activities, North Eastern District; E. G. Horton, secretary-treasurer, Connecticut Section; H. F. Brown; B. H. Caldwell; E. R. Coop; W. S. Fielding; C. D. Hewitt; H. C. Lindberg.

Subcommittees for the meeting, with their chairmen, were

Finance Committee: H. O. Anderson, chairman

Technical Program Committee: H. F. Brown, chairman

Publicity and Printing Committee: F. W. Buck, chairman

Student Program Committee: A. G. Conrad, chairman

Hotel and Registration Committee: E. D. Lynch, chairman

Entertainment Committee: J. A. Nixon, chairman

Trips and Transportation Committee: W. A. Upham, chairman

Ladies' Program Committee: Mrs. C. A. Williams, chairman

Analysis of Registration at New Haven, Conn.

Classification	Conn. Section	District 1*	Other Districts	Total
Members	119	157	57	333
Student Members	39	63	2	104
Men guests	69	84	28	181
Women guests	22	22	7	51
Totals	249	326	94	669

* Outside Conn. Section.

North Eastern District Meeting Attendance 1937–48

Date	Location	Attendance
1948—Apr. 28–30	New Haven, Conn.	669
1947—Apr. 23–25	Worcester, Mass.	828
1946—Apr. 24–26	Buffalo, N. Y.	439
1944—Apr. 19–20	Boston, Mass.	630
1943—Apr. 8–9	Pittsfield, Mass.	319
1942—Apr. 29–May 1	Schenectady, N. Y.	481
1941—Apr. 30–May 2	Rochester, N. Y.	355
1939—May 3–5	Springfield, Mass.	439
1938—May 18–20	Lenox, Mass.	417
1937—May 5–7	Buffalo, N. Y.	352

North Eastern District Executive Committee Meets at New Haven

The executive committee of the North Eastern District held its regular spring meeting April 29, 1948, at the Taft Hotel in New Haven, Conn., incidental to the North Eastern District meeting there. The meeting began with luncheon and extended throughout the afternoon. Vice-President E. W. Davis presided, flanked by District Secretary Victor Siegfried and Dean E. R. McKee, chairman of the District committee on student activities. Visitors included Secretary H. H. Henline, Editor G. R. Henninger, and Chairman J. F. Walker of the District meeting committee.

AGENDA

The following 12 items constituting the agenda for the meeting all came in for a full share in the extended discussion. The highlights of the various points are reflected, and principle actions taken are indicated.

1. Remarks on AIEE affairs, by Vice-president Davis, Secretary Henline, and other officers present.

Secretary Henline mentioned some of the current developments in AIEE activities, drawing especial attention to the greater latitude and flexibility of the Institute's new technical organization. He reflected the Institute's continuing objective to serve electrical engineers wherever they may be, not withdrawing from any division of the electrical field just because some other organization may be active in that particular division of the field. Editor Henninger called attention to the continuing evolution of the new publication program which was initiated in January 1947, mentioning particularly the newest phase, beginning in the current May issue of *ELECTRICAL ENGINEERING* of publishing one-page digests of technical program papers instead of the previous 150- or 200-word abstracts.

2. Remarks from District meeting committee, J. F. Walker, general chairman.

Situation under control.

3. Student Branch activities by Dean E. R. McKee.

Thirteen of the 18 Student Branches in the District have reported a total of 73 Student Branch meetings from October 1947 through April 1948, with an average attendance of approximately 58 persons per meeting. Of the Branch meetings, 44 featured outside speakers, 14 were business sessions, and the remainder were divided about equally between motion pictures, inspection trips, and student talks. The number of reported meetings ranged from two to ten per Branch, averaging between five and six.

4. Membership committee report to the District by F. S. Bacon, Jr.

Extended discussion included suggestions that AIEE membership is an honor available to qualified persons, and that membership promotion should be along these lines and along the lines of continuing technical education; that care should be exercised in the transfer of 6-year Associates to assure that only those fully qualified technically should be transferred from Associate to full Member; that appropriate procedure should be established by each Section for the screening of membership and of transfer applications to assure that only qualified cases adequately presented should be forwarded to headquarters for the national membership committee action, to avoid confusion and annoyance from rejected membership applications.

5. Sections committee report to the District by R. G. Porter and Victor Siegfried; (A) Activities on Section financing; (B) Activities on prize paper awards.

Professor Porter of the Boston Section reported that Section activities throughout the District were strong, with only minor exceptions; that electrical engineering students again were exceeding in quantity those in other branches of engineering, and urged Student Branch counselors to do a consistent and intelligent selling job to attain better balance of student interest between electronics and power subjects; that there was room for much improvement in the range of joint activities and effective co-operation between Sections and Student Branches in their territory. District Secretary Siegfried presented a preliminary report of a study on Institute's finances, with special attention to the question of Section finances and possible economies or adjustments of Section program so as to get more in effective activities with the money available. He suggested that each Section carefully should study both its fixed and its variable expenses, not only currently but in prospect for immediately forthcoming years. He pointed out that inflation adjustments were just as necessary to the Sections as individual adjustments have been. He called attention to the changes governing technical paper prize awards (*EE, Dec '47, pp 1248–9*).

6. Comments on Section activities projects, Subsections, technical groups, and so forth, by Section chairmen.

General consensus that formation of both Subsections and technical discussion groups materially adds to the scope of interest of local Section activities, interests new members, and increases total attendance and individual participation.

7. District committee on nominations, by R. V. Shepherd of Schenectady Section.

The operation of the newly established procedure in the North Eastern District will assure that each Section has a direct opportunity to participate in District nominations for District and national officers.

8. Board of directors' changes in bylaws regarding District organization and Section territory, including progress report on New Hampshire Subsection.

Action on proposed New Hampshire Subsection still pending.

9. Authorization to hold student conventions during spring of 1949, due to presence of national technical meeting in District at Swampscott, Mass., June 20–24, 1949.

Authorizing action taken, in accordance with action of Student Branch representatives at New Haven conference, a meeting will be held at the University of Vermont at a date to be announced later.

10. Section and Branch visits by the vice-president for remainder of year.

11. Date for fall executive committee meeting in Schenectady to be Friday, September 24, 1948.

12. Any other business which may be presented.

Invitation of Syracuse Section for 1951 North Eastern District meeting tentatively accepted. 1950 meeting definitely scheduled for Providence, R. I.

District Student Conference Held During New Haven Meeting

As is indicated elsewhere in these news pages in the analysis of registration at the recent North Eastern District meeting at New Haven, the student participation was characteristically heavy. Three of the technical sessions were given over to the presentation of student papers.

An executive business meeting of Student Branch counselors and Student Branch chairmen for the District was held as a luncheon meeting at the Taft Hotel in New Haven, Conn., Friday, April 30, 1948. Dean E. R. McKee of the University of Vermont, and chairman of the District committee on student activities, presided. Most of the 18 Student Branches in the District were represented at the meeting. Present also were President Hull, Vice-president E. W. Davis, District Secretary Victor Siegfried, Secretary H. H. Henline, Editor G. R. Henninger, and Professor H. W. Bibber of Union College, Schenectady.

Chairman Dean McKee reported that 13 of the 18 Student Branches in the District had reported a total of 73 Student Branch meetings between October 1947 and April 1948 with an over-all average attendance of about 58 persons per meeting; no reports received from the other five Student Branches. Of the 73 Branch meetings reported, 44 featured outside speakers, 14 were business sessions, 5 presented motion pictures, 5 presented student talks, 4 were held as field inspection trips, and 1 was a purely social meeting.

Several useful suggestions for Branch activity were made by Student Branch chairmen in response to chairman McKee's request for Branch reports and suggestions. The Student Branch at Worcester Polytechnic Institute reported that it had been instrumental in arranging a very successful informal conference session between the engineering faculty and engineering student representatives, presided over by a moderator not associated with either group. The session featured a frank and uninhibited exchange of gripes, explanations, and constructive suggestions which resulted in a greatly improved mutual understanding and resulted also in some changes in curricula and procedure. Both students and faculty were reported to have agreed on the mutual value of the conference.

Another Student Branch urged that a definite thread of continuity be established between successive Student Branch meetings. For example, an outside speaker may address a Student Branch meeting on some current topic of technical interest, and this same topic could be developed further at the next Student Branch meeting through student discussion of the same topic, which could lead to the development of student papers on the same general topic for a third Branch meeting. One Student Branch reported that it had developed considerable *esprit de corps* by volunteering as a group and serving as a team in the policing of a section of the campus on a campus clean-up day. As to ways and means of developing student papers, and student participation in Branch meetings, it was agreed generally that the most effective means was continuing heavy promotion by the Student Branch counselor and the Student Branch chairmen.

Formal action was taken to accept the invitation of the University of Vermont to hold the 1949 Student Branch convention of the North Eastern District at that school, inasmuch as the scheduling of the 1949 summer general meeting at Swampscott, Mass., will preclude the holding of a District meeting that year. It was agreed generally that the preferred date for holding such a student meeting would be during the last week in April, the actual date to be subject to later confirmation.

A general discussion of the organization and conduct of the student sessions at the New Haven meeting led to the following general suggestions for the guidance of future activities:

1. More effort on the part of each Student Branch to stimulate local student paper competitions, in collaboration with local Sections wherever possible, for the purpose of stimulating more student papers and to screen the best student papers for presentation at the District conventions.

2. That for the purpose of the student sessions at the District student conventions each school should be limited to a maximum of two student papers, with corresponding efforts to get more schools active in the program.

3. That in general the presentation of undergraduate papers should be segregated from the presentation of graduate papers, especially where the presentations are competitive for prizes or other recognitions.

1948 Lamme Medal Nominations Due December 1

Special attention is directed to the fact that the names of Institute members who are considered eligible for the AIEE Lamme Medal, to be awarded early in 1949, may be submitted by any member in accordance with section 1 of article VI of the bylaws of the Lamme Medal committee, as follows:

> The committee shall cause to be published in one or more issues of *ELECTRICAL ENGINEERING*, or of its successors, each year, preferably including the June issue, a statement regarding the Lamme Medal and an invitation for any member to present to the secretary of the Institute by December 1, the name of a member as a nominee for the medal, accompanied by a statement of his "meritorious achievement" and the names of at

least three engineers of standing who are familiar with the achievement.

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievements of the nominee, to enable the committee to determine its significance as compared with the achievements of other nominees. If the work of the nominee has been of a somewhat general character in co-operation with others, specific information should be given regarding his individual contributions. Names of endorsers should be given as specified in the foregoing quotation.

James Woodford Awarded Fortescue Fellowship

The Charles LeGeyt Fortescue Fellowship committee has awarded a fellowship of $1,000 for graduate study in electrical engineering, 1948–49, to James B. Woodford, Jr., who expects to receive the degree of bachelor of science in electrical engineering at the Carnegie Institute of Technology in June 1948.

Mr. Woodford was born in Upland, Calif., February 27, 1928. He is a member of Tau Beta Pi and Eta Kappa Nu. By June 1948, he will have completed, in addition to the regular undergraduate work, approximately 75 per cent of the requirements for a degree of master of science.

His graduate research is to be devoted to transition times in electronic switching circuits, and is expected to supply electrical engineers with much more accurate methods for predicting the steepness of pulses generated by multivibrators and trigger circuits.

Philadelphia Section Inspects Southwark Generating Station

The Southwark generating station of the Philadelphia Electric Company recently was the object of an inspection trip by 562 members and guests of the Philadelphia (Pa.) Section. The station represents the latest addition to the generating capacity of the company, and consists of two 150,000-kw units, one of which was in operation.

The trip, one of the most successful ever conducted by the Section from the attendance standpoint, required about two hours and included a complete tour from the coal handling equipment to the transmission cable terminals. Sandwiches, ice cream, cakes, and coffee were served to the visitors as they completed the tour.

R. P. Liversidge, superintendent of the Philadelphia Electric Company, welcomes W. R. Clark and H. H. Sheppard, chairman and secretary, respectively, of the Philadelphia Section, to the Southwark generating station; K. J. Falck, supervising engineer of the Philadelphia Electric Company, is at far right

PERSONAL • • • • •

L. N. McClellan (A '14, F '38, past vice-president), for the past three years assistant chief engineer, United States Bureau of Reclamation, Denver, Colo., has been appointed chief engineer. Except for service as a lieutenant in the United States Army during World War I and less than a year with the Southern California Edison Company, Los Angeles, he has served continuously with the Bureau of Reclamation since his graduation from the University of Southern California with a degree of bachelor of science in electrical engineering in 1911. Mr. McClellan has been a member of several AIEE committees: power transmission and distribution, 1933–36; automatic stations, 1937–39; application to mining work, 1937–38; and special committee on use of silver as substitute for copper and aluminum in electrical installations, 1943–44. He was vice-president representing the North Central District (number 6) for the term 1937–39 and he is a past chairman of the Denver Section. In 1946 he was a United States delegate to the World Power Conference, Paris, France.

W. R. Hough (A '35, M '41) chief engineer, Reliance Electric and Engineering Company, Cleveland, Ohio, has been elected engineering vice-president. A native of Kalamazoo, Mich., he joined the company in 1929, following graduation from the University of Michigan. He was successively junior engineer, chief draftsman, a-c design engineer, and product development engineer prior to becoming chief engineer in 1945. Mr. Hough has been secretary (1940–41) and chairman (1944–45) of the AIEE Cleveland Section; his AIEE committee activities include serving on the electric machinery committee since 1942, and the Sections committee 1945–47. He also is a member of the Association of Iron and Steel Engineers.

J. W. Ferguson (A '40) superintendent of inside construction, city light department, Seattle, Wash., has retired after more than 42 years of service with the department. He was born in Kansas City, Mo., November 28, 1879, attended schools in Seattle, and first was employed by the city lighting department in 1906 after ten years of electrical work. In 1915 he was placed in charge of the construction and maintenance of substations for the municipal street railway, and in 1929 was made superintendent and assistant engineer of the inside construction division of the lighting department. Mr. Ferguson formerly was an AIEE Associate from 1919 to 1921.

Wright Canfield (A '31, M '38) head of the research department, Public Service Company of Oklahoma, Tulsa, has been appointed assistant to the president. In his new position he will be in charge of rates and in general will be an economist for the company. Mr. Canfield was placed in charge of operating statistics for the company in 1930, shortly after he received the degree of bachelor of science from Oklahoma Agricultural and Mechanical College. Later he was assigned to the general engineering department, and after several operating assignments was made head of the research department.

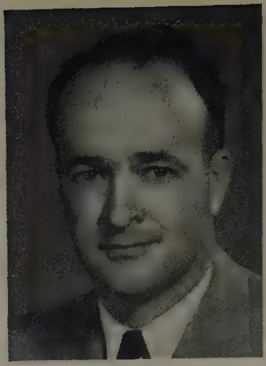
B. M. Carothers (A '42) who has been project engineer, engineering and construction department, Union Electric Company, St. Louis, Mo., has been appointed electrical engineer.

J. E. S. Thorpe (A '06, M '12, member for life) president of Mantahala Power and Light Company, Franklin, N. C., has been elected president of the Southeastern Electric Exchange. Mr. Thorpe came to the United States in 1890 from his native England, and obtained an electrical engineering degree in 1905. He was associated with companies in Porto Rico, Mexico, and Canada before joining a subsidiary of the Aluminum Company of America in 1915. He has been president of the Mantahala Power and Light Company since 1929.

F. H. Searight (A '38) formerly manager of the San Francisco, Calif., district office of the Allis-Chalmers Manufacturing Company, and more recently Pacific region saw mill specialist, has retired. Mr. Searight, who joined the company in 1911, served as sales representative and assistant manager prior to becoming manager of the San Francisco office. During his many years with the company he designed and sold steam power

L. N. McClellan

M. L. Stoughton



W. R. Hough

Melville Eastham

plants for many utilities and saw mills on the West Coast.

R. B. J. Brunn (A '34) senior radio engineer, Hazeltine Electronics Corporation, Little Neck, N. Y., recently was awarded a certificate of commendation by the United States Navy for his achievements during World War II. The citation read in part: "This award is made for your outstanding ability and great personal efforts . . . and the design, development and continued improvement of land navigation beacons, air-borne identification equipments and radar beacons."

Melville Eastham (A '19, F '46) chief engineer and former president of the General Radio Company, Cambridge, Mass., received the 1948 New England Award at the annual meeting of the Engineering Societies of New England. A scroll of illuminated parchment suitably inscribed, the New England Award is given each year to "a living engineer, resident in New England, who, by outstanding achievement, shall merit recognition of his accomplished work as well as of his character, by his fellow engineers of New England." Mr. Eastham, who was president of General Radio Company from 1915 to 1944, served on the AIEE instruments and measurements committee from 1926 to 1931, and has been a member of the communications committee since 1945 after serving previously from 1936 to 1942. His society memberships include the Institute of Radio Engineers, American Association for the Advancement of Science, Acoustical Society of America, American Physical Society, and the American Meteorological Society.

D. R. Boise (A '46) formerly in the district office of the Allis-Chalmers Manufacturing Company at San Antonio, Tex., has been named manager of the company's Amarillo, Tex., district office. Since 1939, he has served in the company's Denver, Colo., and Washington, D. C., offices as well as in San Antonio.

W. S. Hill (A '25, M '30) manager of engineering, Locke Incorporated, Baltimore, Md., has been appointed vice-president of engineering. Mr. Hill was graduated from the University of Nevada in 1923, and was formerly district engineer of the General Electric Company in charge of the Buffalo, N. Y., area. In 1946 he was transferred to Locke Incorporated as manager of engineering in charge of all engineering acitivites. He was secretary of the AIEE New York Section during the year 1944–45, and was a member of the AIEE membership committee from 1940 until 1944. He currently is serving on the AIEE committee on constitution and bylaws.

M. L. Stoughton (A '43) has been appointed Philadelphia (Pa.) district sales manager for I-T-E Circuit Breaker Company and its subsidiary, the Railway and Industrial Engineering Company. He will head the new combined sales office of the two firms in Philadelphia. A graduate of Worcester Polytechnic Institute, he has had more than 20 years of electrical engineering and sales work, and has been with the I-T-E company since 1942 in Philadelphia and Chicago, Ill.

R. D. Teasdale (A '46) Mount Lebanon, Pa., who is studying at the Illinois Institute of Technology under a grant of the Gerard Swope fellowships, is a winner of recently awarded fellowships and thus will be enabled to continue his research.

J. F. Bailey (A '29, M '35) vice-president of the Florida Power Corporation, St. Petersburg, has been appointed vice-president in charge of operations. Mr. Bailey also is president of the Georgia Power and Light Company, Valdosta. After serving for a number of years in various executive positions for utility companies in the Middle West, Mr. Bailey became division manager of the Florida Power Corporation in 1930, and eight years later was named vice-president and general manager of Georgia Power and Light Company; subsequently he was named president. In 1944 he became assistant to the president of the Florida Power Corporation and the following year was made vice-president. He was chairman of the AIEE Florida Section 1935–36.

H. B. Sargent (M '40) president of the Central Arizona Light and Power Company, Phoenix, has been elected to the board of the American Institute of Foreign Trade.

J. W. Anderson (A '23, M '39) assistant superintendent, Philadelphia (Pa.) division, Philadelphia Electric Company, has been appointed division superintendent. He entered the employ of the company as assistant electrical designer following experience with engineering firms in West Virginia and New York. During his work with the company he has been design calculator, senior electrical designer, engineer, engineer of system planning, and superintendent of engineering division, transmission and distribution department. Mr. Anderson served on the AIEE power transmission and distribution committee during the year 1940–41.

L. M. Keating (A '22) assistant to the president in charge of distribution, A. O. Smith Corporation, Milwaukee, Wis., has been appointed executive administrator of the southwest district office of the company in Houston, Tex.

R. O. Lanoue (A '47) has been appointed manager of the Boston, Mass., district of Locke Incorporated, an affiliate of the General Electric Company. He formerly had been associated with the Boston Edison Company and the Western Massachusetts Electric Company, Springfield. During World War II he served two years in the United States Navy as chief electrician's mate.

W. R. G. Baker (A '19, M '47) vice-president, electronics department, General Electric Company, Syracuse, N. Y., has been elected a vice-chairman of the electrical standards committee of the American Standards Association, representing the Radio Manufacturer's Association on this committee. Doctor Baker currently is chairman of the AIEE communication and science co-ordinating committee, and is past president of the Institute of Radio Engineers.

J. J. Pilliod (M '17, F '34) assistant chief engineer, operation and engineering department, American Telephone and Telegraph Company, New York, N. Y., has been made a member of the executive committee of American Standards Association and will represent AIEE in the association.

O. M. Swain (M '45) formerly electrical design engineer, engineering department, Westinghouse Electric Corporation, Lima, Ohio, now is section manager of universal and d-c motors section.

F. M. Terry (A '22, M '28) since 1935 rate engineer of the Consolidated Edison Company of New York (N. Y.), Inc., has been appointed associate rate engineer and will devote himself to special studies and assignments in the field of electric and gas rates.

He was graduated from Union College in 1920 and has been in the office of the rate engineer since 1923.

Stephen Freeman, Jr. (A '27, M '45) has resigned as engineer in the electric distribution engineering department, Consumers Power Company, Jackson, Mich., to become assistant professor of electrical engineering at Purdue University, Lafayette, Ind. Prior to joining the Consumers Power Company, he had been employed by the General Electric Company in Boston, Mass., and with a company in Wabash, Ind.

J. J. Mangan (A '44) has been appointed district engineer for the Upper Columbia district of the Bonneville Power Administration, with headquarters at Spokane, Wash. Mr. Mangan has been serving with the Bonneville Power Administration staff at Portland, Oreg., and formerly was district engineer at Eugene, Oreg.

J. H. Ahrens (A '44) who has been safety engineer for the Hartford (Conn.) Electric Light Company for the past year, has been appointed an industrial power consultant in the sales department. He has been with the company since 1937.

M. B. Reed (A '36, M '43) who has been professor of electrical engineering at Illinois Institute of Technology, Chicago, has joined the University of Illinois at Urbana with the same rank. A graduate of the University of Colorado and of the University of Texas, he has been with Illinois Institute of Technology since 1938.

M. M. Hubbard (M '43) chairman, engineering group radiation laboratory, Massachusetts Institute of Technology, Cambridge, has been made assistant director, laboratory for nuclear science and engineering. He received his electrical engineering degree from MIT in 1929.

J. J. Mullen, Jr. (A '39) executive vice-president of Maloney Electric Company, St. Louis, Mo., has been named president. He has been with the company since 1933 and has been executive vice-president since 1936. A former chairman of the committee on apparatus standards of the National Electrical Manufacturers' Association, he still is serving on that committee and on the joint Edison Electric Institute-National Electrical Manufacturers' Association standards advisory committee.

O. W. Hurd (A '38, M '46) has resigned as district engineer of the Upper Columbia District, Bonneville Power Administration, Spokane, Wash.

W. W. Broadbent (A '16, M '46) who has been superintendent of the southern division of the New England Power Association and superintendent of production for the Narragansett Electric Company, Providence, R. I., has been elected vice-president in charge of production for the latter company. A graduate (1910) of Lehigh University, he joined the Narragansett company following service in World War I and in 1925 was named assistant superintendent of generation. He became superintendent in 1941.

R. E. Secord (A '39, M '46) distribution superintendent of the Narragansett Electric Company, Providence, R. I., has been elected vice-president in charge of distribution, and also has been made a director of the Rhode Island Power Transmission Company. A graduate (1924) of the University of New Brunswick, he has been with the Narragansett company since 1930. He is a past chairman of the AIEE Providence Section.

J. R. Cobb (A '45) has resigned as assistant chief, applications and loans division, Rural Electrification Administration, Washington, D. C., to join the Frigidaire Division of General Motors Corporation, Dayton, Ohio, as manager of farm market sales, a new post created in the appliance sales department. A 1934 graduate of Louisiana State University with a bachelor of science degree in electrical engineering, Mr. Cobb was employed as an agricultural engineer before joining the REA staff in 1937 as a utilization representative in the Southeastern and Southwestern areas. He is a member of the American Society of Agricultural Engineers.

T. M. Staehle (A '17) sales manager, specialty transformers, General Electric Company, Fort Wayne, Ind., has been appointed head of a new sales organization in the specialty transformer and ballast division of the apparatus department. Mr. Staehle is a graduate of the University of Wisconsin and has been with the company since 1913 at Pittsfield, Mass., and Fort Wayne. A member of the Illuminating Engineering Society, he has received two government citations for work on advisory committees of the War Production Board.

J. J. Kirkish (A '36, M '42) electrical design engineer, Louis Allis Company, Milwaukee, Wis., has been appointed chief of electrical design. He has been associated with the company's design engineering since 1937.

R. A. Averitt (M '45) application engineer, industrial engineering division, General Electric Company, Schenectady, N. Y., has been named assistant manager in the aviation division of the apparatus department. He is a 1937 graduate of Rose Polytechnic Institute, where he received a degree of bachelor of science in electrical engineering before entering the employ of the General Electric Company.

C. B. Bradish (M '17) designing engineer, industrial control department, General Electric Company, Schenectady, N. Y., has been appointed manager of engineering in the apparatus department, control division.

W. R. Weise (M '46) superintendent, distribution engineering, Cincinnati (Ohio) Gas and Electric Company, has been appointed assistant superintendent of electric distribution.

M. E. Bretschneider (A '32, M '39) the been named director of employment of has Kansas City Power and Light Company, Kansas City, Mo., after serving as assistant superintendent of the meter and laboratory department since 1944. He is a graduate of Northeastern University and has been with the company since 1931. Mr. Bretschneider is past chairman of the AIEE Kansas City Section.

L. W. Jones (A '45) foreman of the meter shop, Kansas City Power and Light Company, Kansas City, Mo., has been named assistant superintendent of the meter, service and laboratory department. He has been employed by the company since 1928.

R. W. Graham (A '18, M '31) formerly electrical superintendent, Bethlehem Steel Company, Lackawanna, N. Y., has been appointed assistant general superintendent, Homestead (Pa.) district works, Carnegie Illinois Steel Corporation.

E. D. A. Geoghegan (A '36) formerly chief engineer in the engineering department of the Tobe Deutschmann Corporation, Canton, Mass., has been appointed factory manager for the Chicago, Ill., plant of the Solar Manufacturing Corporation. He previously had been employed in various positions by the Polymet Manufacturing Corporation, Radio Corporation of America, and Sprague Electric Company. He will be in complete manufacturing charge of the company's paper capacitors.

D. G. Kells (M '36) system engineering department, Consolidated Edison Company of New York (N. Y.), Inc., has been appointed rate engineer. A graduate of Brooklyn Polytechnic Institute with a degree in electrical engineering in 1923, he entered the rate engineer's office of the New York Edison Company in 1925 and later was made assistant rate engineer, a title which he retained following the company mergers which formed the Consolidated Edison Company in 1936.

N. L. Towle (A '20, M '24) whose appointment as acting dean of the Cooper Union School of Engineering, New York, N. Y., was announced recently (*EE, May '48, p 507*) has been appointed dean.

R. R. Kime (M '44) sales engineer, Westinghouse Electric Corporation, New York, N. Y., has been awarded the Westinghouse "order of merit" for outstanding ability demonstrated throughout his 39 years with the company. He has been assigned to the New York office since 1912.

H. M. Jalonack (M '36) assistant to manager of the transformer division, General Electric Company, Pittsfield, Mass., has been appointed manager of sales planning in the transformer and allied products division. A graduate of Syracuse University, Mr. Jalonack has been with the company for 31 years, serving as district transformer specialist, assistant sales manager, and later sales manager of distribution transformer and feeder regulator section, in addition to his last position. He has received a Charles A. Coffin Foundation award from the company for performing work of outstanding merit. He is a member of the American Standards Association, National Electrical Manufacturers Association, and the Edison Electric Institute. In his new position he will supervise the developing of sales programs.

C. A. Mabey (M '48) formerly director of research, The Bristol Company, Waterbury, Conn., has joined the staff of the electronics division, National Bureau of Standards, Washington, D. C. Mr. Mabey was graduated from Harvard College in 1928, and did graduate work in physics at Harvard University and Massachusetts Institute of Technology. Since 1936 he had been with The Bristol Company, becoming director of research in 1942. He is a member of the American Physical Society and the Instrument Society of America, and formerly was an AIEE Associate.

L. B. Blalock (A '45) industrial sales supervisor, Texas Power and Light Company, Dallas, has been appointed director of industrial development. He has been with the company since 1925.

OBITUARY • • • •

Eugene Herbert Miller (M '25) deputy sales manager, Sangamo Weston, Ltd., Enfield, Middlesex, England, died March 12, 1948. He was born August 21, 1883, at Charlton, Kent, England, and received his education at schools in England and Germany. His early employment was with the Edison Swan Electric Company, Ltd., London, and Metropolitan Vickers, Ltd., Birmingham; in 1909 he became chief estimating engineer, Ferranti, Ltd., Hollinwood, and three years later became sales manager in the instrument and meter department, British Westinghouse Company, Trafford Park. In 1919 he returned to the Edison Swan Company as manager of the switchgear and meter department, a position which he left in 1927 to become electrical engineer, Ferranti, Ltd., a position which he held until he became sales engineer for British Sangamo Company, Ltd., at Enfield in 1929.

Budd Frankenfield (A '97, M '13, member for life) electrical engineer and author of engineering textbooks, Los Angeles, Calif., died February 1, 1948. Mr. Frankenfield was born February 17, 1873, at Henderson, Minn., and entered Leland Stanford Junior, University in 1891. Three years later he transferred to the University of Wisconsin, where he received the degree of bachelor of science in 1895; the following year he received the degree of electrical engineer. Subsequently he taught at the university and at Pennsylvania State College before entering the employ of the Western Electric Company, Chicago, Ill., in 1899. He returned to the University of Wisconsin as instructor the following year; later he was employed by the Allis-Chalmers Manufacturing Company, Milwaukee, Wis. Since 1909 he had devoted himself to the management of personal affairs.

Howard Elmer Smith (A '44) until recently with the General Electric Company, Newark, N. J., died on April 25, 1948, at Congers, N. Y. He was born October 15, 1901, at Denver, Colo., and received the degree of bachelor of science in electrical engineering from the University of Colorado in 1923. He then entered the test department of the General Electric Company at Schenectady, N. Y., and two years later was transferred to the engineering department, where he engaged in industrial control and steel mill applications. In 1927 he was assigned to the Philadelphia, Pa., offices of the company, and the following year was transferred to the Pittsburgh, Pa., sales office. During the period from 1933 to 1936 he was with the Schenectady Chamber of Commerce and the Raub Supply Company, Lancaster, Pa., after which he returned to the General Electric Company at Schenectady and worked on Hoover Dam and Bonneville Dam hydroelectric installations. In 1937 Mr. Smith was transferred to the engineering department at Newark and was an application engineer when he was forced to retire in December 1947. He formerly was an AIEE Associate from 1925 to 1927.

John Price Jackson (A '92, M '94, F '12, member for life) who was personnel director, Consolidated Edison Company of New York (N. Y.), Inc., when he retired in 1938, died in St. Petersburg, Fla., April 2, 1948. Colonel Jackson was born September 27, 1868, in Philadelphia, Pa., and received the degrees of bachelor of science in mechanical engineering (1887) and mechanical engineer (1892) from Pennsylvania State College and of doctor of science from the University of Pittsburgh. His first position in the electrical industry was as a wireman for the Philadelphia Electric Company in 1889. Later he was associated with the Sprague Electric Company as superintendent of street railway construction before entering the teaching profession as director of the mechanical department of Fisk University in 1890. In 1892 Colonel Jackson was appointed to the faculty of Pennsylvania State College, where he remained until 1913, first as professor of electrical engineering, and later as dean of the college of engineering. He resigned to become state commissioner of labor and industry, and the following year was sent by the governor of the state to study industrial conditions in Europe. During World War I he was commissioned as a colonel in the United States Army, and for distinguished service was decorated by the French and Italian governments; he received a citation from the United States government for meritorious service. He joined the New York Edison Company as assistant to the vice-president in 1924 and two years later was made also manager of the personnel bureau. He became head of the personnel department of the Consolidated Edison Company in 1937. Colonel Jackson was the author or coauthor of several technical books and papers. He served the Institute as a member of the committees on education, 1926–28, and safety, 1926–30 (chairman 1926–28). He also served as Institute representative on the Commission of Washington Awards, National Fire Protection Association, National Fire Waste Council, National Safety Council, and the advisory committee to the Museum of Science and Industry of New York (chairman 1926–37). He was a member of the American Society of Mechanical Engineers, Franklin Institute, Eta Kappa Nu, and other scientific and social organizations.

George Laurence Knight (A '11, M '11, F '17, member for life, past vice-president) died at his home in Brooklyn, N. Y., on March 27, 1948. He had been assistant vice-president for shops and construction, Consolidated Edison Company of New York (N. Y.), Inc., and vice-president, Brooklyn Edison Company, at the time of his retirement in 1942. He was born February 20, 1878, at Haddonfield, N. J., and was graduated from the school of electrical engineering, Drexel Institute, in 1900. In that year he joined the Philadelphia (Pa.) Electric Company as switchboard operator, in 1901 became electrical draftsman, department of equipment, United States Navy Yard, New York, N. Y., and in 1902 mechanical draftsman for the New York Edison Company (later part of Consolidated Edison Company of New York) and manager, Walker Electric Company, Philadelphia, Pa. From 1903 to 1905 he was employed as chief draftsman, Waterside Station, New York Edison Company, and in 1905 he joined the Edison Illuminating Company of Brooklyn (later Brooklyn Edison Company) as chief draftsman. In 1908 he was appointed designing engineer and head of the engineering department, becoming mechanical engineer in 1923, vice-president in charge of mechanical operations in 1932, and vice-president and engineer of construction in 1939. He retained the position of vice-president of the Brooklyn company when he was appointed engineer of construction for Consolidated Edison in 1939 and assistant vice-president of construction and shops in 1941. His work with AIEE has been abundant; it included the board of examiners and the following committees: Standards, finance, executive, headquarters, co-ordination of Institute activities, Edison Medal, meetings and papers, and power generation. He was an AIEE manager 1922–26, and was vice-president representing the New York City District (number 3) for the term 1926–28. He also served as AIEE representative on United Engineering Trustees, Inc., of which he also was a past officer. He was a member of the American Society of Mechanical Engineers.

Charles Irvine Burkholder (A '03, M '13, F '31, member for life) vice-president and chief engineer, Duke Power Company, Charlotte, N. C., died March 13, 1948. He was born at Sterling, Ill., October 9, 1872, and was graduated from the electrical engineering course at the University of Wisconsin in 1896. After a short period of time as city engineer of Sterling and in the employ of the Diamond Meter Company, Peoria, Ill., he entered the testing department of the General Electric Company, becoming assistant to the electrical superintendent at Schenectady, N. Y., a position which he held until 1906. He accepted the position of operating superintendent of the Southern Power Company of Charlotte (now the Duke Power Company) in that year and was made vice-president in charge of operation in 1916. His experience with the company included design, installation, operation, and maintenance of both hydro and steam plants, as well as of transmission lines, substations, and other distributing apparatus. He was a director of the company, and also vice-president and director of the Wateree Power Company and president of the Western Carolina Power Company. In 1938 the University of North Carolina awarded him the degree of doctor of engineering.

DeNyse W. Atwater (A '34) manager of commercial engineering, Westinghouse Lamp Division, Bloomfield, N. J., died April 13, 1948. Born in Newark, N. J., August 14, 1894, Mr. Atwater was graduated from Stevens Institute of Technology in 1916 with a degree in mechanical engineering. He did graduate work in France in 1919, following service with the United States Army during World War I. He joined the Westinghouse company at Bloomfield in 1920 as a lamp engineer, and in 1942 was named manager of the illuminating engineering department, becoming manager of commercial engineering when the two departments were consolidated in 1945. Among special lighting projects in which he was active were the Philadelphia Sesquicentennial celebration in 1926, the Century of Progress Exposition in 1933, and the New York World's Fair and the Golden Gate International Exposition in 1939. Author of many articles on lamps and lighting in the trade and technical press, Mr. Atwater was credited with playing a leading part in the nation-wide campaign for improved lighting through his work as a member of the executive committee of the Better Light-Better Sight Bureau. Mr. Atwater was a member of the AIEE committee on production and application of light from 1935 to 1941 (chairman 1939–41) and from 1945 to 1947; he also was a member of the technical program committee from 1939 to 1941 and for two years served as chairman of the illumination group of the AIEE New York Section. He was president of the Illuminating Engineering Society for the 1938–39 term, was general secretary of that group for three years, and had been an active member of its committees for many years.

William Elsdon-Dew (A '08, F '14, member for life) who retired in 1944 from his position as consulting electrical and mechanical engineer, The Central Mining and Investment Corporation, Ltd., Johannesburg, South Africa, died December 16, 1947, at his home in Durban. Mr. Elsdon-Dew was born at Antigua, British West Indies, July 2, 1870, and after receiving his technical training in England went to South Africa in 1895 where he was appointed engineer to the Transvaal Gold Exploration and Land Company, which subsequently became part of the Central Mining–Rand Mines Group in the Transvaal Gold Mining Estates. When he retired Mr. Elsdon-Dew's association with the South African mining industry extended over a period of nearly 50 years, and he had held the position of consulting engineer for 26 years. He was local honorary secretary of the AIEE, Transvaal, from 1921 to 1946. He also held the offices of the local advisory committee and local honorary secretary and treasurer of the Institution of Electrical Engineers, London, England, for nearly 25 years. He was also a member of the Institution of Civil Engineers. In 1925, for the second time, Mr. Elsdon-Dew was elected president of the Associated Scientific and Technical Societies of South Africa. Just before that he had returned from England where he was the official representative of South Africa at the World Power conference and other technical conferences at Wembley.

Leslie Bennie Gordon (A '25, M '26) director of engineering of the Dayton Rubber Company, Dayton, Ohio, died April 8, 1948. A native of Virginia, where he was born in Nelson county on October 3, 1890, he was graduated from Virginia Polytechnic Institute with a degree of electrical engineer in 1912. Following employment in several electrical positions in Covington, Va., and Cleveland, Ohio, he became chief electrical and power engineer for the Kelly-Springfield Tire Company, Cumberland, Md., in 1923, a position which he held until he left the company in 1942. As vice-president in charge of Navy production, Mr. Gordon was with the Patterson Foundry and Machine Company, East Liverpool, Ohio, from 1942 until 1943, when he assumed the position of vice-president in charge of Navy contracts for the Herring-Hall-Marvin Safe Company, Hamilton, Ohio. From there he went to the Dayton Rubber Company in 1945. He also served for a time as consulting engineer for the Mansfield Tire and Rubber Company, Mansfield, Ohio. Mr. Gordon's articles on technical subjects appeared in many national technical magazines.

Ralph Thorum Adamson (A '44) appplication engineer, Westinghouse Electric Corporation, Los Angeles, Calif., died March 19, 1948. A native of Salt Lake City, Utah, where he was born January 15, 1908, he was graduated from the University of Nevada in 1930 with the degree of bachelor of science in electrical engineering. He then became application engineer with the Westinghouse company, rendering assistance to customers in the selection, application, and maintenance of electric apparatus. He was a member of the Los Angeles Electric Club and was active in work of the Boy Scouts of America.

William Egelinton Reid (M '36) systems development department, Bell Telephone Laboratories, Inc., New York, N. Y., died January 23, 1948. He was born at New York on February 3, 1892, and was graduated from Columbia University in 1915 with the degree of electrical engineer. He then entered the test department of the General Electric Company at Schenectady, N. Y., until two years later he joined the Electric Bond and Share Company, New York. In 1920 he accepted a position in the development and research department of the American Telephone and Telegraph Company, New York, and in 1934 was transferred to Bell Telephone Laboratories, Inc., as engineer in the transmission development department. Much of Mr. Reid's time was spent in the field in connection with the work of the joint subcommittee of the National Electric Light Association, now the Edison Electric Institute, and the Bell System. In this connection, he conducted carrier frequency noise tests along the Mohawk Valley and in California and Colorado. During the war, Mr. Reid's work for the most part was on National Defense Research Council projects having to do with submarine detection. Since that time he had worked on the preparation of text material for Bell System practices covering the apparatus used in radio mobile telephone systems. He was an AIEE Associate from 1918 to 1932.

John William Chipperfield (A '22, M '29) vice-president, Ferranti Electric, Ltd., Toronto, Ontario, Canada, died March 16, 1948. He was born at Hull, England, August 23, 1886, and was educated at schools in England. After several years of power station work in England, he went to Canada in 1912 to the firm of Chapman and Walker, Ltd., in Toronto. Since 1915 he had been with Ferranti Meter and Transformer Manufacturing Company and its successor, Feranti Electric, Ltd., first as transformer designer and engineer, and then as chief engineer. Subsequently he was appointed assistant general manager and later vice-president. During World War II he was in charge of constructing and equipping a new building for the production of intricate instruments and equipment for the control of antiaircraft guns and for naval equipment. Mr. Chipperfield was a member of the Association of Professional Engineers of Ontario.

Charles Robert Post (A '39) member of technical staff, Bell Telephone Laboratories, Inc., New York, N. Y., died February 18, 1948. He was born in New York on November 25, 1901, and received his education at schools in that city. He entered the employ of the Western Electric Company in 1919, becoming installation foreman in 1929. He was engaged in work connected with the development of the cross bar dial central office system, and supervised several installations of this equipment, including one in Washington, D. C. Mr. Post had acted as instructor on all branches of panel and cross bar dial system equipment. He was transferred from Washington to New York in 1943, at which time he entered Bell Telephone Laboratories, Inc.

Oscar Werwath (A '19, M '20) founder and president of the Milwaukee School of Engineering, Milwaukee, Wis., died March 20, 1948. Mr. Werwath was born in Stallupoenen, Germany, May 3, 1880. He received degrees in mechanical and electrical engineering from the Saxony Technical College and pursued graduate studies at the universities of Hanover and Darmstadt. He went to Milwaukee in 1903 to work as an electrician, but soon was serving as an electrical engineering consultant in the area. He established the Milwaukee School of Engineering late that year. Under his guidance it was one of the first engineering schools to adopt a plan of co-operative training permitting students to take part time jobs in industry, thus partially financing their education while receiving practical work experience. He was AIEE Student Branch counselor at the Milwaukee School of Engineering 1930–31, and 1933–38.

Ted Bergrun (A '44) chief electrician, Midland Electric Coal Corporation, Farmington, Ill., died April 1, 1948. A native of Chicago, Ill., where he was born August 20, 1897, he was graduated in electrical engineering from the Bliss Electrical School in 1916. He then became electrical engineer at Marion, Ohio, for the Osgood Company, manufacturers of excavating machinery. Later he engaged in independent power transmission line work, and in 1927 became electrical engineer for the Marion Power Shovel Company at Marion, Ohio, where he was in charge of many field installations of electric equipment, including that used on power shovels for building Hoover Dam. After joining the Midland Electric Coal Corporation in 1933, Mr. Bergrun became active in the work of the National Mining Congress as well as other societies and clubs not associated with the electrical industry. He had done some teaching of electrical engineering.

William Lewis Puffer (A '93, M '95, F '13, member for life) Wellesley Hills, Mass., for many years a member of the faculty of the Massachusetts Institute of Technology, Cambridge, died March 8, 1948. He was born at Ludbury, Mass., July 15, 1860, and was graduated from Massachusetts Institute of Technology with the class of 1884, when he became a member of the faculty. After more than 20 years at the institute he opened offices as consulting engineer in Boston, Mass., continuing until his retirement.

MEMBERSHIP • •

Recommended for Transfer

The board of examiners, at its meeting of April 15, 1948, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Fellow

Griscom, S. B., advisory engr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Grissinger, G. G., section mgr. design engg., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Hartig, H. E., prof. & head, elec. engg. dept., Univ. of Minnesota, Minneapolis, Minn.
Higgins, N. B., pres., Safe Harbor Water Power Corp.; advisory engr., Pennsylvania Water & Power Co., Baltimore, Md.
Hobbs, M. H., mgr., eng. swgr. & control div., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Jones, C. R., eastern transportation mgr., Westinghouse Elec. Corp., New York, N. Y.
Leitch, J. D., chief engr., Electric Controller & Mfg. Co., Cleveland, Ohio
Maillard, A. L., pres. & mgr. director, Electric League of Indianapolis, Ind.
Malsbary, J. S., elec. engr., Wagner Elec. Corp., St. Louis, Mo.
Rauth, A. W., supt. of elec. lab., Consumers Power Co., Jackson, Mich.
Ross, M. D., turbine-generator sec., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Vaughan, D. C., asst. system planning engr., Potomac Elec. Pr. Co., Washington, D. C.

12 to grade of Fellow

To Grade of Member

Alger, E. C., elec. engr., Bethlehem Steel Co., Quincy, Mass.
Andriessen, A., Cincinnati Gas & Elec. Co., Cincinnati, Ohio
Austin, T. M., elec. engr., U. S. Bureau of Reclamation, Denver, Colo.
Bagley, G. D., chief engr., Union Carbide & Carbon Research Lab., Niagara Falls, N. Y.
Birdsall, L. C., Engr., Automatic Elec. Co., Chicago, Ill.
Bridgwater, M. M., genl. supt., Arizona Power Co., Prescott, Ariz.
Bullen, C. V., dev. engr., Barber-Colman Co., Rockford, Ill.
Cady, C. A., elec. engr., General Radio Co., Cambridge, Mass.
Callander, M. B., elec. design engr., B. C. Electric Rly. Co., Ltd., Vancouver, British Columbia, Canada
Chidester, J. T., power engr., H. C. Frick Coke Co., Uniontown, Pa.
Christopher, A. J., supervising engr., Bell Tel. Labs., New York, N. Y.
Dana, G. E., relay engr., New York State Elec. & Gas Corp., Binghamton, N. Y.
Donnelly, J. W., engr., Commonwealth & Southern Corp., Jackson, Mich.
Dreischmeyer, E. S., distribution engr., San Joaquin Pr. Div., Pacific Gas & Elec. Co., Fresno, Calif.
Duckwald, C. S., Jr., engr., General Elec. Co., Schenectady, N. Y.
Ford, M A., electronic engr., Bureau of Ships, Washington, D. C.
Fortenbach, J. H., elec. engr., General Elec. Co., Schenectady, N. Y.
Gaylord, C. E., engr., New York Tel. Co., Buffalo, N. Y.
Gravenstreter, P. R., elec. engr., Clark Controller Co., Cleveland, Ohio
Guerdan, D. A., design engr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Hadsel, H., chief elec. engr., American Elevator & Mach. Co., Louisville, Ky.
Hathaway, C. B., mgr., D. C. Engg. Dept., Westinghouse Elec. Corp., Buffalo, N. Y.
Headrick, J. M., elec. engr., Naval Research Lab., Washington, D. C.
Hull, S. B., engr., Southwestern Bell Tel. Co., Dallas, Tex.
Huntley, E. D., section engr., generator div., General Elec. Co., Schenectady, N. Y.
Johnson, R. H., asst. div. engr., General Elec. Co., Ft. Wayne, Ind.
Jung, H. E., sr. distribution engr., Southern Calif. Edison Co., Los Angeles, Calif.
Kenefake, E. W., asst. sec. engr., General Elec. Co., Syracuse, N. Y.
Kent, M. F., sec. engr., turbine divs., General Electric Co., Schenectady, N. Y.
Kirkwood, L. W., member, technical staff, Bell Tel. Labs., Inc., New York, N. Y.
Kronmiller, C. W., asst. mgr. of engg., transformer div., General Electric Co., Ft. Wayne, Ind.
Lamberger, E. H., engr., industry engg. dept., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Livingood, H. L., distribution engr., N. Y. State Elec. & Gas Corp., Binghamton, N. Y.
Lory, M. R., mgr., a.c. motor sec., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Massey, J. T., gen. foreman, Pacific Gas & Elec. Co., San Francisco, Calif.
Meador, J. T., elec. engr., Southern Elec. Service Co., Charlotte, N. C.
Meyer, W. G., consulting & app. engr., Westinghouse Electric Corp., Portland, Oreg.
Miller, M. L., development engr., gov. projects div., Farnsworth Television & Radio Corp., Ft. Wayne, Ind.
Moloney, T. O., Jr., vice-pres. & genl. mgr., Moloney Elec. Co., St. Louis, Mo.
Monfort, C. E., Jr., substation operating engr., Union Elec. Co. of Mo., St. Louis, Mo.
Mullen, J. J., Jr., pres., Moloney Elec. Co., St. Louis, Mo.
Notley, C. K., supt. elec. equipment, Key System Transit Lines, Oakland, Calif.
Parsons, J. E., genl. engr., Chesapeake & Potomac Tel. Co., Washington, D. C.
Paulus, C. F., elec. engg. dept., Cleveland Elec. Illuminating Co., Cleveland, Ohio.
Perry, N. W., elec. engr., General Electric Co., Schenectady, N. Y.
Piper, R. W., Jr., engg. representative, Westinghouse Elec. Corp., San Diego, Calif.
Potter, B. F., engr., University of N. C. Service Plants, Chapel Hill, N. C.
Rahill, E. J., div. plant engr., western div., N. Y. Tel. Co., Buffalo, N. Y.
Russo, R., elec. engr., Clark Controller Co., Cleveland, Ohio.
Saracino, F. E., plant mgr. & engr., Manistee Salt Wks., Manistee, Mich.
Shollenberger, R. R., section engr., Elliott Co., Ridgway, Pa.
Smith, J. J., elec. engr., General Electric Co., Schenectady, N. Y.
Smith, P. C., asst. to div. mgr., Westinghouse Elec. Corp., East Pittsburgh, Pa.
Sontag, R. E., mgr., The Okonite Co., St. Louis, Mo.
Stage, H. C., radio engr., U. S. Naval Research Lab., Washington, D. C.
Stewart, D. J., vice pres. & genl. mgr., Barber-Colman Co., Rockford, Ill.
Strong, W. F., application engr., General Elec. Co., Schenectady, N. Y.
Thiessen, W. F., product engr., control div., General Elec. Co., Schenectady, N. Y.
Thomas, R. E., elec. design engr., Pacific Island Engrs., San Francisco, Calif.
Tugby, E. E., planning engr., Southern Calif. Edison Co., Los Angeles, Calif.
Wallace, J. M., section mgr., Westinghouse Elec Corp., East Pittsburgh, Pa.

61 to grade of Member

Applications for Election

Applications have been received at headquarter from the following candidates for election to membership in the Institute. Any member objecting to the election of any of these candidates should so inform the secretary before June 21, 1948, or August 21, 1948, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Fellow

Yadoff, O. I., Columbia University, New York, N. Y.

1 to grade of Fellow

To Grade of Member

Anderson, C. A., University of Pittsburgh, Johnstown, Pa.
Archibald, L. W., California Elec. Power Co., Riverside, Calif.
Badenoch, J. C., General Elec. Co., Richland, Wash.
Blair, H. F., Western Elec. Co., Cicero, Ill.
Bogar, R. S., Bethlehem Steel Co., Johnstown, Pa.
Buck, D. T., Buck Engineering Co., Inc., Freehold, N. J.
Caldwell, G. A., Bell Telephone Co. of Canada, Toronto, Ontario, Canada
Cardwell, D. W., Oak Ridge Natl. Lab., Oak Ridge, Tenn.
Carmichael, J., Western Elec. Co., Allentown, Pa.
Carter, C. W., Rayner Construction, Thessalon, Ontario, Canada
Cofer, T. F., Western Union Tel. Co., New York, N. Y.
Coleman, R. E., Jr., Bell Telephone Labs., New York, N. Y.
Coles, E. F., H. K. Ferguson Co., Inc., New York, N. Y.
Embry, R. S., Sr., TVA, Knoxville, Tenn.
Ferguson, M. T., Canadian Intl. Paper Co., Three Rivers, Quebec, Canada
Fitzsimmonds, C. A., E. B. Badger & Sons, London, England
Frost, R. W., Henschel Corporation, Amesbury, Mass.
Griffin, N. L., U. S. Public Health Service, Div. of Hospital Facilities, Washington, D. C.
Hicks, J. D., Tampa Elec. Co., Tampa, Fla.
Krzyzanowski, M. J. B., French Tramway & Power Co., Shanghai, China
Lindholm, P., Western Elec. Co., Inc., Kearny, N. J.
Mariscal, J. F., Dept. of Water & Power, Los Angeles, Calif.
Morath, E., AB Elektrolux, Stockholm, Sweden
Munter, K. B. O., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
Odreman, M. A., Luz Elec. de Venezuela, Caracas, Venezuela, South America
Reichert, H. E., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Romzick, L. H., The Detroit Edison Co., Detroit, Mich.
Schumaker, I. R., General Elec. Co., Schenectady, N. Y.
Stallings, T., Pennsylvania Elec. Co., Johnstown, Pa.
Stronach, R. M., 425-B Elmgrove Ave., Providence, R. I.
Trevino, G. L. (re-election), S. R. Rosoff Ltd. & Govt. Dept. of Communications, Mexico, Federal District, Mexico
Turner, W. R., W. R. Turner Co., Los Angeles, Calif.
Vaillant, F., Etablissements Japy Freres, Beaucort, France
Vogelsang, C. A., The Brown Instrument Co., Philadelphia, Pa.
Whitney, C. F., Navy Dept., Bureau of Ships, Washington, D. C.
Wicker, D. A., REA—U. S. Dept. of Agriculture, Washington, D. C.
Wood, W. R., The Berwind-White Coal Mining Co., Windber, Pa.
Wright, H. A., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Yu, Y. P., N. D. Agricultural College, Fargo, N. Dak.

39 to grade of Member

To Grade of Associate

United States, Canada, Mexico, Puerto Rico, and Hawaii

1. North Eastern

Barker, H. J., Rensselaer Polytechnic Institute, Troy, N. Y.
Bjontegard, A. M., General Elec. Co., Lynn, Mass.
Blair, C. L., U. S. Navy Underwater Sound Lab., New London, Conn.
Bosnak, R. J., U. S. Coast Guard Academy, New London, Conn.
Britten, H. H., General Elec. Co., Schenectady, N. Y.
Broadbooks, F. T., Stromberg Carlson Co., Rochester, N. Y.
Broselow, S. D., Dept. of Army, Corps of Engineers, Unadilla, N. Y.

DePuy, S. M., General Elec. Co., Schenectady, N. Y.
Ettlinger, L. F., General Elec. Co., Schenectady, N. Y.
Fairman, F. E., III, General Elec. Co., Schenectady, N. Y.
Falk, B., Simonds Saw & Steel Co., Lockport, N. Y.
Halpin, E. J., Jr., General Elec. Co., Schenectady, N. Y.
Harris, R. V., Taylor Inst. Co., Rochester, N. Y.
Hovee, H. J., General Elec. Co., Lynn, Mass.
Jambro, J. D., Intl. Graphite & Electrode Corp., Niagara Falls, N. Y.
Kaestle, F. L. (re-election), General Elec. Co., Schenectady, N. Y.
Katz, H., General Elec. Co., Schenectady, N. Y.
Krieble, R. H., General Elec. Co., Schenectady, N. Y.
MacLain, J. W., N. Y. State Institute of Applied Arts & Sciences, Utica, N. Y.
Myers, H. C., General Elec. Co., Schenectady, N. Y.
Picozzi, V. J., General Elec. Co., Schenectady, N. Y.
Rawson, R. J., 3 Channing Place, Cambridge, Mass.
Rhoads, H. E., General Elec. Co., Schenectady, N. Y.
Richardson, L. R., Stromberg Carlson Co., Rochester, N. Y.
Robinson, H., General Elec. Co., Schenectady, N. Y.
Rockey, K. O., General Elec. Co., Schenectady, N. Y.
Wilkes, R. W., General Elec. Co., Schenectady, N. Y.
Witham, H. E., General Elec. Co., Schenectady, N. Y.

2. MIDDLE EASTERN

Angell, A. W., Jr. (re-election), I-T-E Circuit Breaker Co., Philadelphia, Pa.
Beck, C. A., Jr., Reliance Elec. & Engg. Co., Cleveland, Ohio
Blanchard, F. A., Lafayette College, Easton, Pa.
Bogatay, F. J., Cleveland Elec. Illuminating Co., Cleveland, Ohio
Cook, J. F., Cleveland Elec. Illuminating Co., Cleveland, Ohio
Cornell, A. R., Westinghouse Elec. Corp., Cleveland, Ohio
Cressman, S. S., Cleveland Elec. Illuminating Co., Cleveland, Ohio
Day, M. L., General Elec. Co., Philadelphia, Pa.
Dowis, D. F., Reliance Elec. & Engg. Co., Cleveland, Ohio
Drum, B. H., Westinghouse Elec. Corp., Johnstown, Pa.
DuCoty, R. L., Ohio Public Service Co., Elyria, Ohio
Duffett, C. W., Jr., Elec. Controller & Mfg. Co., Cleveland, Ohio
Germann, J. S., Gilbert Assocs., Inc., Reading, Pa.
Hambor, J. G., Western Elec. Co., Allentown, Pa.
Harper, E. B., Jr., Reliance Elec. & Engg. Co., Cleveland, Ohio
Hartman, D. G., Westinghouse Elec. Corp., E. Pittsburgh, Pa.
Hugus, J. A., Gulf Research & Development Co., Pittsburgh, Pa.
Kerchner, W. J., Jr., Gilbert Assocs., Inc., Reading, Pa.
Kornichuk, A., Elec. Controller & Mfg. Co., Cleveland, Ohio
Lackner, R. V., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
Lantz, F. V., Gilberts Assoc. Inc., Reading, Pa.
Lester, J. W., The Ohio Public Service Co., Warren, Ohio
Luchsinger, J., Pisecki Helicopter Corp., Morton, Pa.
Mathias, R. R., General Elec. Supply Corp., Johnstown, Pa.
Mitchell, B. B., Gilbert Assocs., Inc., Reading, Pa.
Mitchell, T. C., Remington-Rand, Inc., Washington, D. C.
O'Connor, I., American Die & Tool Co., Reading, Pa.
Pfanner, P. K., Dayton Power & Light Co., Dayton, Ohio
Piazza, F. D. (re-election) Pennsylvania Elec. Co., Johnstown, Pa.
Reininger, J. H., Trailmobile Co., Cincinnati, Ohio
Rohrer, W. M. Jr., University of Pittsburgh, Johnstown, Pa.
Ryder, P. M., Curtiss Wright Corp., Columbus, Ohio
Scorgie, D. G., Naval Research Lab., Washington, D. C.
Skillman, H. I., Gilbert Assocs., Inc., Reading, Pa.
Stockton, K. A., Westinghouse Elec. Corp., Cleveland, Ohio
Tulloss, J. C., Western Elec. Co., Inc., Baltimore, Md.
Wagner, B. C., Gilbert Assocs., Inc., Reading, Pa.
Wang, T., Major, Ministry of Natl. Defense, Chinese Signal Dept., Washington, D. C.
Weschler, W. H., Speed Control Corp., Wickliffe, Ohio
Zambotti, B. M., Cleveland Elec. Illuminating Co., Cleveland, Ohio

3. NEW YORK CITY

Ahmad, M. M., (Gov't. of Pakistan) Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.
Burch, J. E., Jr., Fairchild Aerial Surveys, Inc., New York, N. Y.
Chestoski, A. B., Parsons, Brinckerhoff, Hogan & MacDonald, New York, N. Y.
Christ, H. J., Board of Transportation, New York, N. Y.
Corson, B. R., Intl. Business Machines Corp., New York, N. Y.
Deacon, N. E., AMC Watson Labs., Red Bank, N. J.
Dooley, R. E., Socony-Vacuum Oil Co., Inc., New York, N. Y.
Dusault, A. J., Westinghouse Elec. Corp., Bloomfield, N. J.
Elice, S. S., American Tel. & Tel. Co., New York, N. Y.
Giordano, A. F., Allen B. DuMont Labs., Clifton, N. J.
Hesse, H. R., Princeton University, Princeton, N. J.
Flum, E., Warner, Inc., New York, N. Y.
Hong, S. H., Western Elec. Co., Newark, N. J.
Jacobs, M. M., Puerto Rico Water Resources Authority, Utuado, Puerto Rico
Kapp, J. D., 986 Arnow Ave., New York, N. Y.
MacDonald, R. W., Bell Tel. Labs., Inc., New York, N. Y.
Mendes, F. E., III, N. J. Bell Tel. Co., Newark, N. J.
Paszkowski, J. B., Westinghouse Elec. Corp., New York, N. Y.
Rocamora, R. L., Gibbs & Hill Inc., New York, N. Y.
Samuelson, H. A., Western Union Tel. Co., New York, N. Y.
Schem, F., Underwriters Labs., Inc., New York, N. Y.
Stansfield, F. H., N. Y. Tel. Co., New York, N. Y.
Sugarman, R. H., Rutgers University, New Brunswick, N. J.
Weber, G. A., Western Elec. Co., Newark, N. J.
Williams, R. J., N. Y. Technical Inst., New York, N. Y.
Wilson, J. V. G., U. S. Military Academy, West Point, N. Y.
Woolley, S. L., Rutgers University, New Brunswick, N. J.

4. SOUTHERN

Branum, P. V., Carbide & Carbon Chemicals Corp., Oak Ridge, Tenn.
Davey, J., Louisiana Power & Light Co., Sterlington, La.
Elmstrom, R. E., Atomic Energy Comm., Oak Ridge, Tenn.
Elwes, F. C., Raybro Elec. Supplies, Inc., Jacksonville, Fla.
Hatker, N. W. (re-election), T. V. A., Chattanooga, Tenn.
Headrick, W. A., Carbide & Carbon Chemical Corp., Oak Ridge, Tenn.
Humphries, E. M., Southwestern Gas & Elec. Co., Shreveport, La.
Johnston, W. D., T. V. A., Chattanooga, Tenn.
Kent, H. G., Hagaman Elec. Co., Oak Ridge, Tenn.
Moeller, W. G., T. V. A., Wilson Dam, Ala.
Neale, L. M., Walterboro Broadcasting Co., Walterboro, S. C.
Nelson, D. H., Corps of Engineers, Norfolk, Va.
Peebles, J. B., Jr., General Elec. Co., Jacksonville, Fla.
Pryor, H. D., Carbide & Carbon Chemical Corp., Oak Ridge, Tenn.
Snedegar, R. R., Appalachian Elec. Power Co., Roanoke Va.
Sneed, D. H. (re-election), American Tel. & Tel. Co., Charolotte, N. C.
Stafford, R. J., Florida Power & Light Co., Sarasota, Fla.
Swartz, W. P., Jr., Wm. P. Swartz Jr. & Co., Inc., Roanoke Va.
Way, E. L., Southern Bell Tel. & Tel. Co., Baton Rouge La.
Wheeler, V. J. H., R. 2, Box 46, Cleveland, Miss.
Wyckoff, R. Q., Florida Power & Light Co., W. Palm Beach, Fla.

5. GREAT LAKES

Carroll, J. E., Divane Bros., Chicago, Ill.
Compton, R. L., Caterpillar Tractor Co., Peoria, Ill.
Crafton, H. C., Commonwealth & Southern Corp., Jackson, Mich.
French, C. R., Consumers Power Co., Jackson, Mich.
Hartson, R. H., Intl. Harvester, Chicago, Ill.
Hefner, C. W., United Light & Railway Service Co., Des Moines, Iowa
Hetherington, R. M., Illinois Gas & Elec. Co., Davenport, Iowa
Hicks, H. E., Bemis Bag Co., Peoria, Ill.
Johnson, R. H., Westinghouse Elec. Corp., Saginaw, Mich.
Kopan, R. I., Standard Oil Co., Chicago, Ill.
Lefferts, O. D., Commonwealth & Southern Corp., Jackson, Mich.
Lubin, L. T., General Elec. Co., Chicago, Ill.
Moseley, W. J., Jr., United Light & Rwys. Service Co., Davenport, Iowa
Nelson, A. H., West Central Broadcasting Co., Peoria, Ill.
Pearson, E. R., Koontz-Wagner Elec. Co., South Bend, Ind.
Petersen, J. H., Barber-Colman Co., Rockford, Ill.
Poehlmann, G., P. R. Mallory & Co., Indianapolis, Ind.
Randall, C. W., (re-election) Box 93, Baker, Minn.
Raymer, D. G., Central Ill. Public Service Co., Springfield, Ill.
Smits, A., Delta-Star Elec. Co., Chicago, Ill.
Ward, J. D., Commonwealth Edison Co., Chicago, Ill.
Wilczyk, S. S., Waldorf Paper Products Co., St. Paul, Minn.
Witthoft, H. C., Anaconda Wire & Cable Co., Marion, Ind.
Wyatt, W. H. H., General Elec. Co., Chicago, Ill.

6. NORTH CENTRAL

Baptist, J. V., U. S. Bureau of Reclamation, Denver, Colo.
Hawley, C. L., Omaha Public Power District, Omaha, Nebr.
Hendrickson, C. R., Omaha Public Power District, Omaha, Nebr.
Matejka, H. L., Omaha Public Power District, Omaha, Nebr.
Pace, J. P., Omaha Public Power District, Omaha, Nebr.
Porter, H. B., Northwestern Bell Tel. Co., Omaha, Nebr.
Prai, H. W., Omaha Public Power District, Omaha, Nebr.
Richardson, W. A., Henningson Engr. Co., Omaha, Nebr.

7. SOUTH WEST

Baer, A. W., Sverdrup & Parcel, Inc., St. Louis, Mo.
Brunkhorst, R. B., Southwestern Bell Tel. Co., Dallas, Tex.
Cope, I. E., I. E. Cope & Co., Dallas, Tex.
Crawford, J. D., Dallas Power & Light Co., Dallas, Tex.
Goebel, H. C., Southwestern Bell Tel. Co., St. Louis, Mo.
Hall, W. H., Texas A. & M. College, College Station, Tex.
Hanpeter, J. A., A. B. Chance Co., Centralia, Mo.
Hoehn, G. L., Jr., Geotronic Labs., Inc., Dallas, Tex.
Holiman, W. E., Electrical Sales Co., Houston, Tex.
Hubbard, J. W., The Empire District Electric Co., Aurora, Mo.
Kelso, J. B., University of Oklahoma, Norman, Okla.
Kurz, G., Montajes y Reparaciones, S. A., Tacubaya, Federal District, Mexico
Leavenworth, M. H., Dow Corning Corp., Dallas, Tex.
Manly, F. D., Refineria Pemex, Atzcapotzalco, Mexico
Moore, W. C., U. S. Army Corps of Engineers, Little Rock, Ark.
Robbins, W. L., South Western Bell Tel. Co., Dallas, Tex.
Robles, G., Jr., Ave. Juarez 76-404, Mexico, Federal District, Mexico
Schaefer, R. A., Missouri School of Mines, Rolla, Mo.
Selke, A. P., Lower Colorado River Authority, New Braunfels, Tex.
Stoddard, H. G., Texas Power & Light Co., Dallas, Tex.
Trammell, J. J., The Atlantic Refining Co., Sour Lake, Tex.
Tumy, R. W., General Elec. Co., Dallas, Tex.
Walters, P. H., Lower Colorado River Authority, Austin, Tex.
Warwick, F. N., Lower Colorado River Authority, New Braunfels, Tex.
Wilcox, C. C., Southwestern Bell Tel. Co., San Antonio, Tex.
Wilkinson, J. D., Wilkinson Bros., Dallas, Tex.

8. PACIFIC

Braun, H. P., Pacific Gas & Elec. Co., Sacremento, Calif.
Carlson, J. V., Public Utilities Comm., San Francisco, Calif.
Cox, L. D., Hawaii Inst. of Technology, Honolulu, Hawaii
Cromar, E. R., Warner Bros. Studio, Burbank, Calif.
Dailey, D. W., Bone Engg. Co., Glendale, Calif.
Davis, M. B., 707 Scott St., Redwood City, Calif.
Desmond, A. J., Dept. of Water & Power, Los Angeles, Calif.
Dimmick, W. F., Safety Center, Berkeley, Calif.
Dutton, J. C., The Pacific Tel. & Tel. Co., San Francisco, Calif.
Felt, W. G., Bureau of Reclamation, Sacramento, Calif.
Fredrickson, M. A., Southern California Edison Co., Alhambra, Calif.
Green, R. H., Minneapolis Honeywell Regulator Co., San Francisco, Calif.
Hawkins, A. R., Consolidated Vultee, San Diego, Calif.
Krauss, F. H., Electrical Facilities Inc., Oakland, Calif.
Laughead, R. R., Pacific Gas & Elec. Co., Stockton, Calif.
Malcho, R. E., 1014 W. 36th St., Los Angeles, Calif.
Melton, B. M., Continental Can Co., San Jose, Calif.
Moody, R. D., Allis-Chalmers Mfg. Co., San Francisco Calif.
Penn, E. J., Westinghouse Elec. Corp., Emeryville, Calif.
Potter, L. A., C. F. Braun & Co., Alhambra, Calif.
Sammer, B. N. (re-election), The Fluor Corp., Ltd., Los Angeles, Calif.
Sasine, E. G., Dept. of Water & Power, Los Angeles, Calif.
Sherwood, W., Dept. of Water & Power, Los Angeles, Calif.
Smith, G. Z., Pacific Tel. & Tel. Co., Los Angeles, Calif.
Tank, L. J., San Diego Gas & Elect. Co., San Diego, Calif.
Veit, W. A., Southern California Edison Co., Los Angeles, Calif.
Wallace, W. L., California Elec. Power Co., Riverside, Calif.

9. NORTH WEST

Beck, A. W., Butte Machinery Co., Butte, Mont.
Bell, H. L., Sr., The Kellex Corp., Richland, Wash.
Cornelius, R. C., Dept. of Lighting, Seattle, Wash.
Downie, W. I., Trumbull Elec. Mfg. Co., Seattle, Wash.
Fritz, H. L., Tacoma City Light, Tacoma, Wash.
Kliebenstein, W. W., Kellex Corp., Richland, Wash.
Smith, G. E., Bonneville Power Admin., Vancouver, Wash.
Zamzow, H. T., Kyle Co., Portland, Oreg.

10. CANADA

Clark, N. S., B. C. Elec. Railway Co., Vancouver, British Columbia, Canada
Dravis, J. J., Canadian Westinghouse Co. Ltd., Montreal, Quebec, Canada
Herbert, R., 91–4th St., Shawinigan Falls, Quebec, Canada
McPherson, E. L., B. C. Elec. Railway Co., Vancouver, British Columbia, Canada
Moore, D. C., B. C. Elec. Railway Co., Vancouver, British Columbia, Canada
Morris, D. T., Canada Wire & Cable Co., Vancouver, British Columbia, Canada
Perron, G. A., Hydro-Quebec, Montreal, Quebec, Canada
Philip, R. H., Trafalgap Public Utilities Comm., Oakville, Ont., Canada
Ritchie, R. R., Montreal Engg. Co. Ltd., Montreal, Quebec, Canada

Elsewhere

Balani, N. J., Central Technical Power Board Cleremont, Simla, India
Hare, J., A. Reyrolle & Co., Hebburn-on-Tyne, Durham England
Freymodsson, J. B., Federation of Iceland Co-Operative Societies, Reykjavik, Iceland
Joslin, W. J., Creole Petroleum Corp., Caripito, Venezuela, South America
Purcell, J. O., Electricity Supply Board, Dublin, Ireland
Sansom, T. B., Bruce Peebles Co., Edinburgh, Scotland
Shah, V. K., The United Eastern Agencies Ltd., Fort, Bombay, India
Varma, H. R., Central Electricity Comm., Cleremont, Simla, India
Venugopal, V. R., Capt., (Gov't. of India), 40, Laxman Mudaliar Street, Bangalore, South India

Total to grade of Associate
United States, Canada, Mexico, Puerto Rico, and Hawaii, 218
Elsewhere, 9

OF CURRENT INTEREST

Navy Recruiting Personnel for Research Laboratories

Implementing its scientific research and development program both geographically and in new fields of endeavor, the Navy Department currently is expanding three comparatively new, permanent laboratories in California. Heretofore, the Navy Department's scientific centers have been concentrated in the eastern and eastern seaboard areas.

Two of the laboratories have been established as the logical outgrowth of programs carried on by universities during the war. The Naval Ordnance Test Station, China Lake (formerly Inyokern), Calif., 160 miles from Los Angeles, originally was an activity of the California Institute of Technology. Its present program involves research, development, and test work with ordnance equipment and explosives. The Navy Electronics Laboratory at San Diego, Calif., is the outgrowth of work done by the University of California. It is concerned with research, testing, and development of electronic control devices, detection equipment, instrumentation equipment, and training aids. The Naval Air Missile Test Center at Point Mugu on the coast of California, 60 miles north of Los Angeles, was established when the need for an installation became apparent as the result of the Navy Department's activities on guided missiles. The Test Center's activities are concerned with flight and laboratory testing and evaluation of guided missiles and their components.

Each of the establishments has current need for qualified personnel in a variety of scientific fields to staff its laboratories. Recently completed at the Naval Ordnance Test Station is Michelson Laboratory at a cost of $6,000,000. Many more millions of dollars have been spent in equipment and facilities. Additional construction and facilities are planned for both the Air Missile Test Center and the Electronics Laboratory.

The work programs of the laboratories are planned, directed, and accomplished under the direction of an outstanding staff of civilian scientists. Extensive use is made of the council method of operation. Constant liaison is maintained with other research organizations, universities, scientific associations, and outstanding authorities throughout the nation.

Professional positions are in the career service of the Federal government under Civil Service laws. Examinations are now open in the three scientific establishments in the following professional fields: chemist, mathematician, metallurgist, meteorologist, physicist, statistician, scientific research administrator, and scientific staff assistant.

Examinations are also open in the following branches of the engineering profession: aeronautical, chemical, civil, electrical, electronics, general, industrial, material, mechanical, metallurgical, ordnance, safety, and structural.

Salaries for most of the positions range from $3,397 to $9,975 per year. Salaries are predicated on the level of ability, knowledge, and experience required to discharge effectively the duties of a specific position.

Federal employment at one of the Navy Department's laboratories offers professional personnel an opportunity to make a significant scientific contribution by working with top flight scientists under a progressive administration; 26 working days of paid vacation and 15 days of paid sick leave each year; a liberal retirement program; transfer privileges; advancement contingent upon demonstrated ability; and opportunities for further education and self-development.

Further information may be obtained from the Navy Department Joint Board of United States Civil Service Examiners, 1030 East Green Street, Pasadena 1, Calif.

NRC Announces Fellowships for Atomic Energy Research

The National Research Council has announced a new program of fellowships supported by funds provided by the Atomic Energy Commission as a part of the commission's responsibility for future atomic energy research. Accordingly, these fellowships will be awarded in the many fields of science related to research in atomic energy.

A considerable number of these fellowships is available to young men and women who wish to continue in graduate training or research for the doctorate in an appropriate field of science. Others of these fellowships will provide training in biophysics applied to the control of radiation hazards. An additional number of fellowships will be assigned to those below the age of 35 who already have achieved the doctorate and who wish to secure advanced research training and experience in those aspects of the physical, biological, and medical sciences related to atomic energy. Tenure of the fellowship does not impose on the fellow any commitment with regard to subsequent employment.

The candidates will be selected by the fellowship boards of the National Research Council established for this program. In the postdoctoral field, there will be three groups of fellowships, the basic stipend of which will be $3,000. In the predoctoral field, the program provides for two groups of fellows with stipends ranging from $1,500–2,100.

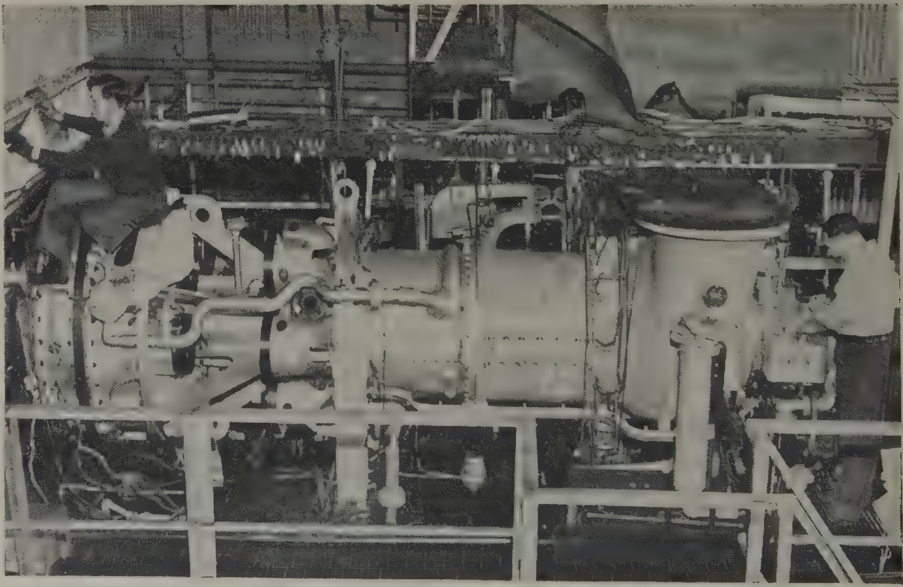
Fellowships will be granted for study and research in universities or other nonprofit research establishments approved by the fellowship boards. Awards will be made for the academic year 1948–49. Supervision of a fellow's program of work will be under the direction of the fellowship boards of the National Research Council. Further information can be secured by writing to the Fellowship Office, National Research Council, 2101 Constitution Avenue, Washington 25, D. C.

New Physics Magazine Features Nontechnical Approach

With the publication of the first issue of *Physics Today*, dated May 1948, the American Institute of Physics presents a new semipopular magazine designed to interpret rapid strides being made in the science of physics for the benefit of the nonspecialized reader.

The new magazine, under the editorship of David A. Katcher, physicist and science

Developmental Locomotive Gas Turbine



The developmental locomotive gas turbine of the General Electric Company is shown on its test stand at Schenectady, N. Y. The turbine, rated at 4,800 horsepower, has been operated in factory tests since September 1947. It is similar in arrangement to to the *TG-180* aircraft gas turbine which now powers fast military airplanes

writer, will appear monthly. Most of its articles will be written by scientists. The major article in the first 40-page issue is "Trends in American Science," by Doctor Vannevar Bush (F '24) wartime director of the Office of Scientific Research and Development, and now director of the Research and Development Board.

News departments in *Physics Today* include a "Washington Letter," "Institute Doings". "Notes From Abroad," news from academic and industrial laboratories, and summaries of lectures and meetings of physicists throughout the United States.

Subscription price for the new magazine is $4 per year.

NEC Issues Proceedings of 1947 Conference

The "Proceedings" of the 1947 National Electronics Conference now is available at $4 a copy from Doctor R. R. Buss, NEC Secretary, care of the Electrical Engineering Department, Northwestern Technological Institute, Evanston, Ill. Copies of the 1946 and 1944 "Proceedings" also are available, at $3.50 and $3 a copy, respectively.

The 1947 "Proceedings" contain a total of 712 pages, including a complete list of exhibitors at the 1947 conference. The papers have been classified and grouped for easy reference. Some of the more general of the 19 classifications are television, antennas and wave propagation, infrared and microwave systems, air navigation systems, electronic instrumentation, computers, induction and dielectric heating, frequency modulation, and nuclear physics.

Dellinger Retires From NBS. Doctor J. Howard Dellinger, former chief of the central radio propagation laboratory of the National Bureau of Standards, Washington, D. C., retired recently after 40 years of Government service. Doctor Dellinger is known for fundamental research in radio—a major achievement was the discovery of the simultaneous occurrence of solar eruptions and radio fadeouts, since called the "Dellinger effect"—and also for his work with the national and international conferences held to discuss radio problems in the past 35 years.

Portable Leak Detector Developed by General Electric

A new portable leak detector especially designed for production testing of hermetically sealed units such as are used in refrigerators, deepfreezers, and air conditioners in which halogen compound is the refrigerant, has been announced by the General Electric Company. Other applications of this instrument include locating leaks in tanks, boilers, piping, and other closed systems into which halogen compounds can be introduced as a tracer.

The detector unit is a hand-held probe with a pistol grip, having a metal nozzle with a plastic tip. The unit contains a sensitive element which is responsive to halogens in the air, and a motor-driven blower which circulates the air through the sensitive element. An 8-foot cable lead is supplied to connect the detector unit to the control unit.

The control unit is a self-contained, portable unit containing the power supply, amplifier, indicating instrument, necessary controls, and a carrying strap. A 25-foot lead is supplied for connecting the control unit to the power supply.

New Capacitor Paper Permits 25-Kilovar Units

A new low-loss Kraft paper developed by the General Electric Company has raised the ceiling rating for large power factor capacitors to 25 kilovars, ten kilovars higher than the practical design limit that has stood for the past 15 years. Size of the new 25-kilovar unit is about 58 per cent larger than that of the 15-kilovar capacitor.

This 67 per cent increase in capacity is obtained chiefly because the new paper has a 20 per cent lower temperature rise than the dielectric previously used, according to General Electric engineers. Past attempts to build larger than 15-kilovar capacitors have been blocked by the problem of dissipating more watts loss from the case without increasing maximum operating temperature.

The decrease in case area per kilovar of rating is offset by the lower watts loss of the new Kraft paper. Tests have revealed that temperature rises of a 15-kilovar capacitor with standard paper and a 25-kilovar unit with the new paper were within three per cent of each other at the maximum allowable operating condition of 135 per cent of rating.

Significant installation advantages are obtained. For example, the increased unit capacity permits more kilovars at the pole top; 225 kilovars can be mounted on a single pair of cross arms, as compared with a 180-limit using 15-kilovar units. There are less units to handle and fewer connections necessary with 25-kilovar units.

318 Engineering Societies Described in New Yearbook

"The Engineering Societies Yearbook, 1948" published in early March by The American Society of Mechanical Engineers, under the sponsorship of The Engineers Joint Council, describes eight international engineering organizations, 275 United States societies, and 35 Canadian societies, as the first of what is planned to be a periodical series of this reference source on the purposes, activities, membership, policies, and new developments of all engineering societies, clubs, and councils.

Engineering joint bodies, national, regional, state, and local organizations are included. There are also sections on student branches of the national societies, on engineering employee organizations, state registration boards, and on accredited engineering colleges and curricula.

This information has been classified and indexed to assist governing bodies and secretaries of all the societies by facilitating liaison on matters of common concern. In each case this involves contacts with other engineering societies, colleges, publishers, libraries, research groups, trade associations, industries, and government agencies. Data for the "Yearbook" were secured by the circulation of special questionnaires.

The five societies sponsoring the "Yearbook" (AIEE, American Institute of Mining and Metallurgical Engineers, American Society of Civil Engineers, ASME, and American Institute of Chemical Engineers) report a total of 119,588 members in the Fall of 1947, of whom 22,517 are student members. It is estimated that there will be approximately 337,000 members of the engineering profession by 1950.

The price of the "Yearbook" is $3. Copies are available from ASME, 29 West 39th Street, New York 18, N. Y.

Civil Service Announces Various Engineering Vacancies

Civil Service examinations have been announced for filling engineer positions in various Federal agencies in Washington, D. C., and in the Bureau of Reclamation in the States of Oregon, Washington, California, Arizona, Nevada, Idaho, Montana, Wyoming, Colorado, New Mexico, Utah, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas.

Applications for engineer positions in the Bureau of Reclamation, which pay $2,644 a year, are being accepted by the Executive Secretary, Central Board of United States Civil Service Examiners, Bureau of Reclamation, Denver Federal Center, Denver, Colo. To qualify for these positions, applicants must pass a written test. In addition, they must have completed appropriate college study in engineering or must have had technical engineering experience, or a combination of such study and experience. Applications will be accepted from students who expect to complete their college courses not later than October 1, 1948.

The salaries for engineer positions in Washington, D. C., range from $3,397 to $5,905 a year. No written test will be given to applicants for these positions. To qualify, they must have had college study or experience in engineering or a combination of such study and experience, and in addition they must have had professional engineering experience. Graduate study may be substituted for part of the experience.

Age limits for the $2,644 positions in the Bureau of Reclamation are 18 to 35 years, and for the higher level positions in other Federal agencies from 18 to 62 years. These age limits are waived for persons entitled to veteran preference. No deadline has been set for acceptance of applications for positions in the Bureau of Reclamation. Applications for positions in Washington, D. C., must be received in the United States Civil Service Commission, Washington 25, D. C., not later than December 31, 1948.

An examination also has been announced for filling vacancies in the Rural Electrification Administration in the positions of field representative (loan applications and electrical utility management), rural electrification engineer, home economist (electrical), and inspector (poles). Applications are being accepted by the Executive Secretary, Board of United States Civil Service Examiners for the Department of Agriculture, Agricultural Research Center, Beltsville, Md.

Starting salaries for the positions, which are located in Washington, D. C., and throughout the United States, range from $3,397 to $4,902. No written test is required. To qualify, applicants for all positions except that of inspector must have had appropriate college study or experience or a combination of the two, plus appropriate professional or technical experience. Public speaking ability is required for the field representative jobs.

Detailed announcements and application forms for any of the foregoing positions may be secured from the United States Civil Service Commission, Washington 25, D. C., from Civil Service regional offices, or from most first- and second-class post offices.

Curtis Award Presented at EEI Sales Conference

The sixth annual Augustus D. Curtis Award for outstanding achievement in the art of illumination was presented at the 14th annual sales conference of the Edison Electric Institute at the Edgewater Beach Hotel, Chicago, Ill., April 7, 1948.

The fundamental basis for the Curtis Award is higher levels of quality illumination applied in accordance with better light—better sight principles. The Curtis Award gives recognition to the operating utility companies, and to the individual or individuals in those companies who have accomplished most in maintaining these principles.

The four awards for the year of 1947 are as follows:

First prize—Norman E. Tindal, illuminating engineer, Duke Power Company, Charlotte, N. C.

Second prize—C. E. Romberger, commercial lighting supervisor, Luzerne County Gas and Electric Corporation, Kingston, Pa.

Third prize—Lucian T. Kight, supervisor of architects and builders service, Duquesne Light Company, Pittsburgh, Pa.

Fourth prize—Frank Evans, lighting engineer, Indianapolis Power and Light Company, Indianapolis, Ind.

Augustus D. Curtis was the founder of Curtis Lighting, Inc., of Chicago, and the award was established in his memory by the Curtis organization.

NYU Issues New Quarterly Applied Mathematics Journal

The first issue of "Communications on Applied Mathematics" a new quarterly journal published by The Institute for Mathematics and Mechanics at New York University has been issued.

This journal will publish primarily papers originating from and solicited by New York University Institute for Mathematics and Mechanics. It will be devoted mainly to contributions in the fields of applied mathematics, mathematical physics, and mathematical analysis. While most of the papers in the first two issues concern problems of water waves, a great variety of topics is scheduled for the subsequent issues. Among these subjects are

Problems of nonlinear partial differential equations and methods for their numerical solution

Theory of spectral representation and applications to quantum theory

Linear and nonlinear problems in elasticity, including nonlinear vibrations

Fluid dynamics, gas dynamics, and applications to aerodynamics

Problems of combustion

Kinetic theory of gases

Problems of turbulence, and many others

Subscription price for the journal is $8 per year and single copies are $2.50. Inquiries should be addressed to Interscience Publishers, Inc., 215 Fourth Avenue, New York 3, N. Y.

Engineering Societies Library Increases Rates for Services

A study of library operating costs has shown the need for increasing the rates on some of the services of the Engineering Societies Library to make them self-sustaining.

The library board, therefore, has authorized the following rates effective June 1, 1948.

Literature searching (per hour)—$5
Translations (per hundred words)
  German, French, Italian, Spanish—$1.50
  Russian, Dutch, Portuguese, Danish, Swedish—$2
  Japanese, Chinese, Finnish, and so forth—Quotation on request
Photostats (per print)—40 cents
  Minimum charge per order—$1
Microfilm (per article from one volume)—$1.50
Book loans (per week for each volume)—60 cents

Members of the Founder Societies will continue to receive a discount of 20 per cent on searches and on translations, and a reduction of five cents on each photostat print if the work is ordered for their personal use and paid by personal check.

CIGRE Biennial Meeting Scheduled for Paris

The 12th biennial meeting of the International Conference on Large Electric High-Tension Systems (CIGRE) is scheduled to be held in Paris from June 24 to July 3, 1948. More than 100 technical papers on power generation, transmission, and distribution developments will be presented and discussed by more than 1,000 delegates from 40 different countries.

Twelve general sessions will be held, one of which will be devoted to a-c transmission at extra high voltages, for which 16 papers have been contributed from several countries; another of these general sessions will be devoted to d-c transmission at extra high voltages.

Fifteen international study committees will hold individual meetings on operating practice and electric equipment developments, including cables, conductors, insulators, towers, transformers, circuit breakers, and rectifiers, so that the conference will be of interest to all power utility operators and electrical manufacturers. A large United States delegation is expected to attend and 14 technical papers of United States authorship will be presented.

Further information on this conference can be obtained from the Secretary of the United States National Committee of CIGRE, Room 1781, 50 Church Street, New York 7, N. Y.

Educators Exchange Experiences at Inter-Professions Conference

The Inter-Professions Conference on Education for Professional Responsibility was held at Buck Hill Falls, Pa., April 12–14, 1948. This conference, a meeting of 96 educators from the five professional fields of law, medicine, divinity, business, and engineering, was sponsored by the Carnegie Corporation of New York to provide an opportunity for the different professions to assist each other by telling of their experiences in the effort to establish educational programs which would graduate "not only competent practitioners but good citizens and better men and women as well."

By listening to the experiences of others, each of the professions represented was trying to learn more about:

1. What the goals and aims of professional schools should be in this jet-paced world.
2. What type of courses must be included and how these courses can be taught to give professional men and women the best possible start in learning their professions from experience, and the qualities which citizenship in an enduring free society demands of its leaders.

In addition to President Karl T. Compton (F '31) of Massachusetts Institute of Technology, Cambridge, Mass., President Robert E. Doherty (F '39) of Carnegie Institute of Technology, Pittsburgh, Pa., and President Harry S. Rogers of Polytechnic Institute of Brooklyn, N. Y., the engineering profession was represented by 22 other outstanding men in the field.

OTHER SOCIETIES •

RMA Appoints Committee on Industry Mobilization

Appointment of a preliminary committee on problems of industry mobilization and military production was announced recently by the Radio Manufacturers Association. The new RMA government liaison committee will secure information on government industry mobilization and military production plans from the National Security Resources Board, the Munitions Board, the Army, the Navy, and other agencies, as they affect the radio-electronic industry, and will provide for future co-ordinated action between the government and manufacturers of the industry.

Under study by the committee will be facilities and procedure for expanded military production in connection with the greatly enlarged armament program for the Army and Navy being planned by the Congress. Later an expanded RMA committee, or subcommittees, may be appointed to consider various industry interests and problems involved.

Fred R. Lack (M '37) vice-president of the Western Electric Company, Inc., New York, N. Y., has been named chairman of the new committee.

ASTE Elects Officers. Irwin F. Holland, Pratt and Whitney, Hartford, Conn., was named president of the American Society of Tool Engineers for 1948–49 during the

Future Meetings of Other Societies

American Society for Engineering Education. June 14–18, 1948, Austin, Tex.

American Society for Testing Materials. Annual meeting, June 21–25, 1948, Detroit, Mich.

American Society of Agricultural Engineers. Annual meeting, June 20–23, 1948, Portland, Oreg.

American Society of Civil Engineers. Summer convention, July 21–23, 1948, Seattle, Wash.; fall meeting, October 13–15, 1948, Boston, Mass.

Association of Iron and Steel Engineers. Iron and Steel Exposition, September 28–October 1, 1948, Cleveland, Ohio

CIGRE (International Conference on Large Electric High-Tension Systems). Biennial meeting, June 24–July 3, 1948, Paris, France

Edison Electric Institute. Annual convention, June 2–4, 1948, Atlantic City, N. J.

Fluorescent Lighting Association. Show, June 6–10 1948, New York, N. Y.

Illuminating Engineering Society. National technical conference, September 20–24, 1948, Boston, Mass.

Institute of Radio Engineers. Pacific Coast convention, September 30–October 2, 1948, Los Angeles, Calif.

Instrument Society of America. Third instrument conference and exhibit, September 13–17, 1948, Philadelphia, Pa.

National Electrical Manufacturers Association. November 8–13, 1948, Atlantic City, N. J.

Pennsylvania Electric Association. Prime movers committee meeting, June 10–11, 1948, Scranton, Pa.

Pittsburgh International Conference on Surface Reactions. June 7–11, 1948, Pittsburgh, Pa.

Porcelain Enamel Institute. Tenth annual forum, October 13-15, 1948, Urbana, Ill.

society's 16th annual meeting, in Cleveland, Ohio, March 15–19. He succeeds W. B. Peirce of Pittsburgh, Pa., who will remain as a member of the national board of directors. Other officers elected were R. B. Douglas, Godscroft Industries Ltd., Montreal, Quebec, Canada, as first vice-president; H. L. Tigges, Baker Brothers, Inc., Toledo, Ohio, as second vice-president; V. H. Ericson, Johnson de Vou, Inc., Worcester, Mass., as third vice-president; George A. Goodwin, Master Electric Company, Dayton, Ohio, as treasurer; and W. B. McClellan, Gairing Tool Company, Detroit, Mich., as secretary of the ASTE for the new term.

Western Society Moves. The Western Society of Engineers has moved to its new headquarters at 84 East Randolph Street, Chicago, Ill., and thus the 79-year-old organization has taken the lead in establishing an engineering and scientific center in Chicago. Other organizations of similar interests and professional standards will be invited to share in the expanded headquarters. It is estimated that the society will spend approximately $100,000 in renovating and equipping the center. When finished the center will include meeting rooms, offices, lounges, and dining facilities. The center will be housed temporarily on the fourth floor of the Taylor Building while structural and interior changes are being completed on the fifth, sixth, and seventh floors in preparation for the society.

FOREIGN • • • • • • •

Canada—Hydroelectric Developments. The completion of a $10,000,000 hydroelectric project at Campbell River, Vancouver Island, British Columbia, Canada, was celebrated on December 15, 1947, when the first of two 25,000-horsepower units was placed in operation. The plant was planned by the provincial government to furnish power for industrial projects and to provide electric current to rural areas. (*Foreign Commerce Weekly*)

United Kingdom—Standardization of Equipment. All electrical plants in Great Britain of more than 10,000-kw capacity are to be standardized to two main types of generators—30,000 and 60,000 kw. Engineering firms are subject to severe penalties if they manufacture generator sets which do not conform with the license issued by the Ministry of Supply. Exceptions are made for sets ordered prior to November 1, 1946, those produced under license, and those for use on ships and for exports. The use of individual designs is not affected by this order. Further measures of compulsory standardization are contemplated for boilers, steam and water pipes, and valves. (*Foreign Commerce Weekly*)

Haiti—Development Projects. The 4,000,000 gourdes placed at the disposal of the Department of Public Works of Haiti for the establishment of a hydroelectric plant at Onde Verte and irrigation of about 16,000 hectares in Artibonite Valley represent the first installment on projects the total cost of which is estimated at 12,625,000 gourdes. (The gourde is the monetary unit of Haiti established in 1920 as equal to 20 cents in United States gold.) (*Foreign Commerce Weekly*)

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Phase Transformer

To the Editor:

In a recent letter to the editor (*EE, Mar '48, pp 311–12*) J. B. Winther presented a scheme for obtaining transformation from three to two phase alternating current by utilizing a 3-phase wound-rotor induction motor with a locked rotor.

The merits of this application as compared with the standard Scott-T or Taylor 3-transformer method is controversial considering the rare occasions in which such a scheme would be required, and the following comments are offered.

From a design standpoint and permanent installation Mr. Winther's method has definite disadvantages. Butting the rotor core against the stator core by no means would result in the ideal magnetic flux path and low magnetic reluctance as compared with the conventional homogenous transformer core.

This arrangement in turn would lead to comparatively high eddy current loss (iron or core loss), also necessarily larger excitation current. The core ventilation normally present with an air gas and revolving rotor would be absent, and as heating through eddy current loss would be increased, the reduction in heat dissipation cumulatively would be reduced, leading to a reduction in maximum capacity. Also I would expect that as a result of the increased leakage reactance the inherent power factor would be lower than that of the comparative transformer.

Considering the increased eddy current and excitation copper loss, the operating efficiency would be comparatively lower than is usual for the transformer method. Mr. Winther's statement that this device would operate as a frequency changer conflicts with fundamentals, inasmuch as frequency changer is primarily a function of the rotative speed common to both primary and secondary circuits, and secondarily as the comparative number of poles between primary and secondary circuits, for example, a fixed transformer cannot act as a frequency changer, the secondary frequency is exactly the same as the primary frequency disregarding the difference in number of poles.

From an operating viewpoint I would prefer to use the standard transformer method for a permanent or emergency installation where transformers are available, if not then I see no objection to using Mr. Winther's method for emergency use only.

VERNON UTTLEY (M '47)

(Chief Projects Branch, Headquarters United States Army Forces Antilles, Office of the Antilles Engineer, c/o Postmaster, Miami, Fla.)

Voltage Notation Conventions

To the Editor:

With reference to the article, "Voltage Notation Conventions," by Reed and Lewis (*EE, Jan '48, pp 48–1*), the authors say on page 46 that with the recommended convention some difficulty is encountered when it is attempted to attach the subscripts to the ends of a voltage vector.

It is suggested that the difficulty is avoided if the arrowhead is omitted when subscripts are written at the ends of a vector. This often is done as for instance in the preliminary report on a proposed Test Code for Transformers, AIEE, 1931. The direction of the vector is shown by the order in which the subscripts are written.

In Figure 6 of the article the vector V_{ab} then would be considered as directed toward the origin, the vector V_{ba} away from it. The projection of the vector gives correctly the instantaneous voltage and polarity of a with respect to b as the authors point out. Similarly, in drawing vector diagrams for 3-phase systems, it is usually convenient to show the line-to-neutral voltage vectors V_{an}, V_{bn}, and V_{cn} all directed toward the neutral point n, the reference point and origin of the diagram.

G. H. BURCHILL (A '26)

(Professor of electrical engineering, Nova Scotia Technical College, Halifax, Nova Scotia, Canada)

To the Editor:

The article, "Voltage Notation Conventions," by Myril B. Reed and W. A. Lewis (*EE, Jan '48, pp 41–8*), gives a very clear picture of some of the difficulties attendant upon present-day electrical notation and conventions. Of the many conventions possible in double-subscript notation, the one recommended by the authors is, I agree, the best. In my opinion, however, the single-subscript notation is far superior to the double, and I feel that the authors err in leaving the single subscripts on an equal or slightly inferior footing to the double. I believe, also, that it is not possible to consider voltage and current notation apart from the notation for impedance, inductance, and like quantities. I shall indicate how this practice gives rise to certain difficulties in this article. As the article suggests tentative standards, it is important that such difficulties be given careful consideration.

In claiming an advantage for the double subscripts, the authors state " . . . [in the absence of a circuit diagram] it is only with a double-subscript notation that the letter symbols, with their appended subscripts, can give complete information regarding directions of currents and polarities of voltages." If by this it is implied that the single subscripts cannot give complete information, I agree; but, if the implication is also that double subscripts always do give this information, then I must disagree. As an example, refer to Figure 3 in the article. Neither the current I_1, nor the current I_2 can be described completely by double subscripts. What the authors should say is that when *branch* currents are used as the basic current variables (rather than mesh or node currents), then the double subscripts furnish complete information. As the use of mesh currents is at least as common as the use of branch currents, any advantage derived from the use of double subscripts is offset by the necessity of changing to single subscripts for mesh analysis. It is, of course, possible to use double subscripts arbitrarily to represent mesh currents, but this is a questionable procedure.

The authors themselves have indicated the ambiguity which arises when parallel current paths occur. The method they suggest for avoiding this ambiguity (see their Figure 1*B*), while it works successfully for two parallel paths, becomes too cumbersome to be practical when the number of parallel paths is large. Such multiple paths are very common, for instance, in vacuum tube circuits. In such instances, to resolve the ambiguity, it is usual to resort to arrows, appropriately located on the circuit diagram. This is a matter of necessity for single subscripts, and a matter of practical simplicity when double subscripts are used.

The foregoing points are relatively minor and have been covered merely to indicate that, if we base our opinion only on the arguments advanced in the article, the single-subscript notation stands at least on an equal footing with the double subscripts.

The best test for any notation is its application to practical cases, and, to understand the main disadvantage of double subscripts (for voltage and current), we turn now to the worked examples in the appendix of the article. In particular, let us examine more closely the authors' equation 7 and its related circuit in Figure 7*A*.

Consider first the current symbol $i_{aa'}$. In all their argument, and in all their notation throughout the article proper, the authors used a single letter for single subscripts, and two (different) letters to denote double subscripts. Now, without explanation, the appendix suddenly confronts us with a single letter, repeated with a prime, to denote a double subscript. Is it not surprising to find that, having reached a decision as to a preferred notation, the authors, in working this, their first example, promptly abandon it? It must be emphasized that the change is not a trivial one. The subscripts in the expression $i_{aa'}$ tell us that this current flows in circuit a (the primary in Figure 7*A*). Similarly, in the expression $i_{bb'}$, the subscripts tell us that this current flows in circuit b (the secondary). That is, the letters a and b here designate the *current axis* (branch, mesh, or node, in the general case). This is their proper function. The fact that each subscript is repeated, once primed, and once unprimed, and thus also is made to indicate current direction, is relatively unimportant. This is not double-subscript notation, for, if two distinct letters had been used, rather than primes, this separation of quantities into the primary group a and the secondary group b would be lost. On the other hand, if single subscripts had been used, this function would have been accomplished. The expression $i_{aa'}$ is actually a hybrid, compounded of single- and double-subscript ideas, but differing from both.

To make clearer the real meaning of the subscripts, it is necessary to raise a point mentioned earlier in the article, namely, that it is not possible to standardize current and voltage notation separately from notation for quantities such as impedance, inductance, and the like. Consider, from equation 7 in the article, the expression L_{ab}. As the equation is supposedly in double-subscript notation, from the authors' paper, logically we might expect this to be the inductance between the point a and the point b. It is, of course, no such thing, but rather the mutual inductance between the circuit a and the circuit b. To be completely consistent, L_{ab} should have been written $L_{aa'bb'}$. It was to avoid this cumbersome expression that the primed letters were introduced, for the expression $L_{aa'bb'}$ can be contracted to L_{ab} (as is done by Reed and Lewis) and the meaning is still clear. If double subscripts had been used, then the mutual inductance would have appeared something like L_{abcd}, which form could not be contracted without confusion, hence the resort to primed letters. It should be noted that when single-subscript notation is used, the foregoing artifice is unnecessary. I think we all agree that the use of four subscripts for inductance is undesirable.

As a further clarification of the meaning of subscripts, it is helpful to translate literally an equation of simple form such as (in single-subscript notation) $V_a = L_{ab}\cdot\frac{di_b}{dt} + R_{aa}\cdot i_a$. This says, in effect, that the voltage in the circuit (branch, mesh, or node) a (hence V_a) is equal to the flux linking circuit a due to the current in circuit b (hence L_{ab}) multiplied by the rate of change of current in circuit b (hence $\frac{di_b}{dt}$). To this must be added the voltage across the resistance of circuit a (this resistance, recall, is the ratio of voltage in a to current in a, hence R_{aa}) multiplied by the current in a (hence i_a).

Advanced methods of network analysis utilizing matrix and tensor concepts commonly employ an index notation which substantially, is an extension of that denoted by Reed and Lewis as "single subscript." In these advanced methods, the meanings attached to subscripts are roughly those I have indicated here. The single-subscript notation fits smoothly into these more advanced methods of analysis. This the double-subscript notation does not do.

The difficulties which the authors foresee in the application of the double-subscript notation to vector diagrams are not encountered when single-subscripts are used. In addition to the opposition arising out of personal prejudice, the double-subscript vector diagram is objectionable in that it takes our notation still further away from that of other sciences.

One point raised in the article, namely that of suitably designating the terminals of relays and switchboard instruments, is really beyond our purview, and properly belongs in a standard on terminal makings for electric apparatus. Admittedly, it would be desirable to have such markings consistent with the notation used in analysis.

When the paper upon which this article was based was read at the winter meeting in Pittsburgh, the discussion which followed showed that substantial disagreement exists as to double-subscript preferences. One speaker suggested that the subscripts should indicate "the functional identity of the circuit quantity," but otherwise discussion centered on the various double-subscript conventions, and continued, it may be noted, until the time limit expired.

Even if the disagreements over double-subscript conventions finally are resolved, and a standard double-subscript notation achieved, it always will be necessary to note whether a given paper was written before or after the standardization. Why not, then, abandon the double-subscript notation altogether, in favor of the single-subscript type suggested by Reed and Lewis? Confusion with past literature is then impossible, as all double-subscript notation will be suspect (which is a good thing). The only remaining source of confusion will be those former papers using single-subscript notation and a directed arrow—the number of such papers should be relatively small.

In conclusion, therefore, it is proposed that the single-subscript notation, exactly as given by Reed and Lewis, be made the standard notation. If double-subscript notation is included, then I suggest that with it be included notation for such quantities as mutual inductance.

WILFRED G. HOYLE

(Assistant Research Engineer, National Research Council, Ottawa, Ontario, Canada)

English Teachers for Engineers

To the Editor:

The following letter written to Professor W. George Crouch of the department of English at the University of Pittsburgh, Pittsburgh, Pa., regarding his article with Robert L. Zetler in the December issue, pages 1182–4, may be of interest to other readers of *ELECTRICAL ENGINEERING*.

Dear Professor Crouch:

One of my more alert students in technical writing, thinking to raise his midterm grade, told me that a couple of fellows in the December *ELECTRICAL ENGINEERING* had called me a rare bird. I later found that his reference was to the excellent discussion in "Training English Teachers for Engineers," by you and Professor Zetler.

The whole problem of giving and receiving the double-edged training necessary to the teaching of English to engineers for years has been close to the heart of Doctor H. L. Creek (Purdue University) and others in the English Section of the American Society for Engineering Education. Before the war, he seemed on the verge of getting a workable system set up by co-operation between Harvard University and the Massachusetts Institute of Technology; however, the emergency and its hang-over have prevented further ripening of plans. Meanwhile, Doctor Creek is approaching retirement age, and frankly does not plan to take part in aggressive plans from here on out. The task must be undertaken by others; and I am happy to see you and Professor Zetler laying hold so understandingly.

My own experience is a rather frightful example of the financial inadequacy and the academic incomprehensibility of the rigors through which one must pass if he wishes to teach English to engineers. After finishing as an honors graduate in electrical engineering, I did one more year in a technical school, three years in liberal arts universities, and nearly two years and a dissertation in a teachers' college, for the sake of upper degrees in sociology-commerce, literature, and technical writing. This process, plus making a living for *one* person, took 15 years and nearly $10,000. The experience was wonderful in its opportunity to know many institutions of different kinds; but, as I look back now, the most lasting impression of each is its disrespect for both the others.

Moreover, I should have had more encouragement financially, as well as less confusion academically. A little bookkeeping—which I dare not make—probably would indicate that the whole business has been a failure.

It is for these reasons, and many more, that I am happy to see the excellent presentation in *ELECTRICAL ENGINEERING.*

ALVIN M. FOUNTAIN

(Professor of English, North Carolina State College, Raleigh, N. C.)

NEW BOOKS • • • • •

"Who's Who in Engineering." This sixth edition of the publication represents approximately 16,000 engineers, a 12 per cent greater coverage than the fifth edition. As in previous editions, those who are included are engineers of outstanding and acknowledged professional eminence, engineers of at least ten year's active practice (at least five years in charge of important engineering work), or teachers of engineering subjects for at least ten years (at least five years in charge of a major engineering course). Lewis Historical Publishing Company, Inc., New York, N. Y., 2,357 pages, $6^1/_4$ by $9^1/_4$ inches, $15.

"International Industry Yearbook." This is the first issue of what is planned to be an annual publication summarizing the technological progress achieved in the various fields of engineering and industry. It is intended to serve both management and education, as well as the engineering profession, by providing, in a single volume, the over-all picture of the technical advancements of the industry as a whole. Edited by Lloyd J. Hughlett. Kristen-Browne Publishing Company, Inc., New York, N. Y., 1948, 416 pages, $8^1/_2$ by 11 inches, $10.

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

IMPROVING SUPERVISION. By F. Cushman and R. W. Cushman. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1947. 232 pages, tables, $7^1/_2$ by 5 inches, cloth, $2.50. Of interest to foremen and supervisors, this book contains a composite analysis of their responsibilities in a wide variety of industrial and business organizations. It has been designed for "follow-up" reading in connection with supervisory training programs. The basic philosophy of the whole problem of improving supervision is discussed, and the supervisory job is analyzed. Special emphasis is placed on human relations problems.

(The) PHYSICAL PRINCIPLES OF WAVE GUIDE TRANSMISSION AND ANTENNA SYSTEMS. By W. H. Watson. Clarendon Press, Oxford, England; Oxford University Press, New York, N. Y., 1947. 208 pages, illustrations, diagrams, charts, tables, $9^1/_2$ by $6^1/_4$ inches, cloth, $7. The aim of this book is to describe the way in which the technique of handling radio-frequency transmission lines has been extended to deal with propagation through hollow metal pipes known as wave guides. The theoretical and mathematical aspects of the control and transmission of microwaves are emphasized, and dominant wave propagation and loading characteristics are included.

WRITING SCIENTIFIC PAPERS AND REPORTS. By W. P. Jones. William C. Brown Company, Dubuque, Iowa, 1946. 115 pages, diagrams, 11 by $8^1/_4$ inches, paper, spiral binding, $2.50. The general intent of this text is to present students with a number of simple problems in scientific exposition, and to give them instruction and practice in organizing ideas and in communicating these ideas to the reader. Necessary information concerning writing style, sentence structure, punctuation, capitalization, abbreviations, and so forth, is included, as well as the proper physical characteristics of technical reports and other examples of written expression.

ELEMENTARY TELEGRAPHY. By E. Missen. George Newnes Limited, London, England, 1946. 340 pages, diagrams, tables, $7^1/_2$ by 5 inches, cloth, 12s.6d. Elementary principles and modern apparatus are the subjects of this volume. The earlier chapters deal with the various codes employed, the principles of the start-stop telegraph system, telegraph relays, and elementary line telegraph transmission. Subsequent sections have been devoted to voice frequency telegraphy, telegraph circuits, signal distortion, and power supplies. Other features are chapters dealing with testing and measuring apparatus and telegraph instrument room equipment.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, PROCEEDINGS, volume 5, number 1. Edited by C. Lipson and W. M. Murray. Society for Experimental Stress Analysis, Cambridge, Mass.; published and distributed by Addison-Wesley Press, Inc., Cambridge, Mass., 1947. 136 pages, illustrations, diagrams, charts, tables, $11^1/_4$ by $8^1/_2$ inches, cloth, $6. The 15 papers contained in this volume deal with various aspects of the following subjects: strain gauges; impact testing; telemetering; X-ray analysis; fatigue and other stresses. Also included are a list of members, and contents pages for volumes 2, 3, and 4.

STATICS. By J. H. Kindle and H. L. Miller. Ginn and Company, Boston, Mass.; New York, N. Y.; Chicago, Ill.; Atlanta, Ga.; Dallas, Tex.; Columbus, Ohio; San Francisco, Calif; Toronto, Ontario, Canada; London, England; 1947. 171 pages, diagrams., charts, tables, $9^1/_2$ by 6 inches, cloth, $2.60. Designed for use in pre-engineering college courses, this book develops a course in statics based on the principles of action and reaction, transmissibility of a force, vector addition of forces, and static equilibrium. A working knowledge of algebra, geometry, and trigonometry is assumed. Included are several hundred graded problems and their answers. In examples given in the text, a graphical solution first is obtained and is followed by an analytical solution.

STATISTICAL ABSTRACT OF THE UNITED STATES, 68th edition, 1947. Compiled under the supervision of M. H. Hansen. United States Department of Commerce, Bureau of the Census; for sale by the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C. 1,038 pages, charts, maps, tables, $9^1/_4$ by $5^3/_4$ inches, cloth, $2.75. This book presents summary statistics on the industrial, social, political, and economic organization of the United States. It considers primarily national data and limited summaries by States. Serving as a convenient reference volume for quantitative information, it is also a guide to various important sources of statistical data. New features of this 68th issue are graphic material, reorganization of the material on agriculture, and sections on forestry resources, veterans' programs, current industrial production, construction contracts, and on new and discontinued businesses. Principal omissions are tables showing data for the Philippine Islands, as they are no longer a United States possession.

THEORY AND APPLICATION OF MICROWAVES. By A. B. Bronwell and R. E. Beam. McGraw-Hill Book Company, New York, N. Y., and London, England, 1947. 470 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $6. Intended as a text for senior or first-year graduate students, this new book states transmission line equations, the use of impedance diagrams in solving transmission line problems, and transmission line network. Electromagnetic field theory is approached from the viewpoint of Maxwell's equations. Sections deal with the propagation and reflection of plane waves, solution of the wave equations, oscillations of cavity resonators, radiation from antennas, and directional radiating systems. Selected problems are included.

AMERICAN SOCIETY FOR TESTING MATERIALS, PROCEEDINGS, Volume 46, 1946. Committee Reports, Technical Papers. American Society for Testing Materials, Philadelphia Pa., 1947. 1,629 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $12 (ASTM members, $8). This volume presents the committee reports and the technical papers presented at the 48th annual meeting. All the symposia are not presented in full. Those published elsewhere are summarized. Discussions are included and immediately follow the respective papers. A wide variety of materials and material properties are dealt with.

ASTM STANDARDS ON ELECTRICAL INSULATING MATERIALS (with related information). Prepared by ASTM Committee D-9 on Electrical Insulating Materials; Specifications, Methods of Testing; September 1947. 574 pages, illustrations, diagrams, tables, charts, 9 by 6 inches, paper, $4 (ASTM members, $3). This 1947 compilation presents in their latest form some 90 specifications and tests of interest to engineers, purchasers of electrical insulating materials, and other technologists in the electrical and related industries. An index gives detailed listings of the wide range of materials covered and test methods included, and provides references to certain apparatus and discussions on significance of rests.

ULTRA- AND EXTREME-SHORT WAVE RECEPTION, PRINCIPLES, OPERATION, AND DESIGN. By M. J. O. Strutt. D. Van Nostrand Company, Toronto, Ontario, Canada; New York, N. Y; London, England; 1947. 387 pages, illustrations, diagrams, charts, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $7.50. Covering the whole field of short-wave reception, this volume gives an over-all picture of the fundamental methods of practical applications. New techniques, such as wave guides, resonant cavities, and horn and lens antennas, are dealt with in detail. Practical matters, such as disturbances of propagation and the causes of noise are discussed, and the present-day solutions presented. Basic design information for radio receiving equipment from 6 to 30 thousand megacycles is given. A bibliography is included.

WIRING A CONTINENT, THE HISTORY OF THE TELEGRAPH INDUSTRY IN THE UNITED STATES 1832–1866. By R. L. Thompson. Princeton University Press, Princeton, N. J., 1947. 544 pages, illustrations, diagrams, charts, tables, $9^1/_2$ by 6 inches, cloth, $7.50. Primarily an economic history of the development of the telegraph, this volume reveals the general pattern of all industry in the United States in the 19th century. Starting with a biographical sketch of Samuel F. B. Morse, the author goes on to tell of the industrial development of his invention up through the Civil War years, including its effect on the life of the country. A bibliography of manuscript sources, books, and articles is given.

WORK AND EFFORT, THE PSYCHOLOGY OF PRODUCTION. By T. A. Ryan. Ronald Press Company, New York, N. Y., 1947. 323 pages, diagrams, charts, tables, $9^1/_2$ by 6 inches, cloth, $4.50. This book provides a systematic survey of psychological investigations concerned with productivity. Among the problems treated are training and learning, the control of accidents, establishment of pay levels for various jobs, and the design of efficient methods of work. Motivation of the worker is considered in its relation to problems of efficiency. Conclusions drawn from research in various fields are presented, and the methods of research that led to the findings are emphasized.

APPLIED JOB EVALUATION, A MANUAL OF INSTALLATION AND OPERATING METHODS. By H. G. Stanway. Ronald Press Company, New York, N. Y., 1947. 81 pages, charts, tables, $9^1/_2$ by 6 inches, cloth, $3.50. Intended as a manual of installation and operating methods, this book provides a definite and simple program for analyzing, describing, classifying, and rating jobs. Detailed methods are given which may be applied to either large or small firms. A short list of books for reference reading is included.

AUSTRALIA, ITS RESOURCES AND DEVELOPMENT. Edited by G. L. Wood, with a foreword by W. S. Robinson. Macmillan Company, New York, N. Y., 1947. 334 pages, illustrations, maps, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $4. This book is a study of the economic resources of Australia, their present state of utilization, and their possibilities in the immediate future. All the main elements of national wealth are considered, including the new industries developed during the war. Matters of government policy, both national and international, which have a bearing on Australia's economy are treated.

ÉLECTROTECHNIQUE DES ISOLANTS. By J. Granier. Dunod, Paris, France, 1947. 124 pages, diagrams, charts, tables, $8^1/_4$ by $5^1/_4$ inches, paper, 340 frs. Of interest to those who are concerned with design and development of electric equipment, this volume discusses electric insulators. Part 1 is devoted to perfect dielectrics; the loss of electric energy by orientation of molecules, conduction, and hysteresis are considered in part 2; and in part 3 data are given on special insulators such as procelain and varnish. A bibliography on general theory and the specific subjects indicated in the foregoing is included.

COMBAT SCIENTISTS. By L. R. Thiesmeyer and J. E. Burchard; volume editor, A. T. Waterman; foreword by K. T. Compton. Little, Brown and Company, Boston, Mass., 1947. 412 pages, illustrations, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $5. This book tells the story of the field activities of the Office of Scientific Research and Development as instituted and carried out for the purpose of providing the Armed Forces with scientific advice on new weapons, devices, and techniques. The many forms of this assistance, its scope, and a glimpse of the manner in which this activity was organized and operated are presented. Two illustrations of the work are given in the studies dealing with the navigational and demolition aspects of landing operations. Subject and personnel indexes and a glossary of organization and operation abbreviations are included.

FLUID MECHANICS OF TURBOMACHINERY. By G. F. Wislicenus. McGraw-Hill Book Company New York, N. Y., and London, England, 1947. 613 pages, diagrams, charts, tables, $8^1/_2$ by $5^1/_2$ inches, cloth, $7.50. This text presents, in organized form and consistent nomenclature, much of the modern development in theory and practice in the field of water, gas, and steam turbines, centrifugal and axial flow pumps, compressors, propellers, and hydraulic torque converters, and couplings. Its principal subdivisions treat of similarity, general theory of 1-, 2-, and 3-dimensional flow with and without friction, compressible fluids, and geometry of turbomachinery. Various theories are compared, and their limitations as well as their merits are pointed out. There are many references to theoretical and experimental work. It is intended to aid engineers and designers engaged in or responsible for the design and testing of turbomachinery; however, an assortment of examples included at the ends of many of the chapters should make it attractive as a text for advanced or graduate engineering students.

HIGH VACUA, PRINCIPLES, PRODUCTION, AND MEASUREMENT. By S. Jnanananda. D. Van Nostrand Company, Toronto, Ontario, Canada; New York, N. Y. and London, England; 1947. 310 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $5.50. The scope of this book ranges from the choice of suitable vacuum-producing and vacuum-measuring apparatus to the most effective means of control and calibration. Many diagrams show constructional details and working methods. The basic principles of all the equipment used are explained, and the kinetic theory of gases is reviewed.

PRACTICAL ELECTRICAL WIRING, RESIDENTIAL, FARM, AND INDUSTRIAL. By H. P. Richter. Third edition. McGraw-Hill Book Company, New York, N. Y., and London, England, 1947. 574 pages, illustrations, diagrams, charts, tables, $8^1/_4$ by $5^1/_2$ inches, cloth, $3.75. This book presents the terminology, basic principles, and practical wiring instructions for residential, farm, and industrial use. All material is based on the 1947 National Electrical Code, of which appropriate sections appear in the appendix. Changes in this revised edition are in the sections in which the code was altered. The scope of the book has been limited to the wiring of structures of limited size and at ordinary voltages, under 600 volts.

SOUND, A PHYSICAL TEXTBOOK. By E. G. Richardson. Longmans, Green and Company, New York, N. Y.; Edward Arnold and Company, London, England, 1947. 344 pages, illustrations, diagrams, $8^1/_2$ by $5^1/_2$ inches, cloth, $5. This volume deals with the physics of sound and its applications. The results of experimental research are included, as well as a selective survey of the periodical literature from 1907 to date. A knowledge of basic physics and calculus is assumed. In this fourth edition, the material is brought up to date and rearranged to provide a logical progression from the simple characteristics of sound to the modern technological aspects.

HEAT. By A. G. Worthing and D. Halliday. John Wiley and Sons, New York, N. Y.; Chapman and Hall, London, England, 1948. 522 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by $5^3/_4$ inches, cloth, $6. Dealing largely with "classical heat," this book emphasizes experimental methods. Each chapter contains appropriate theory, experimental procedures, results, and problems. Temperature measurement, specific heat, change of phase, and the three standard modes of heat transfer are discussed, as well as elementary thermodynamics and heat engines. Quantum considerations are given some attention.

HISTORICAL APPRAISAL OF MECHANICS. By H. F. Girvin. International Textbook Company, Scranton, Pa., 1948. 275 pages, diagrams, tables, $9^1/_4$ by 6 inches, cloth, $3.25. Tracing the history of mechanics from the early Greeks to modern times this book stresses the relationship of mechanics to engineering education. Divided into three parts, part 1 discusses the early development of science and scientific thinking. The contributions from the Renaissance through Newton are considered in part 2, while part 3 is devoted to the mechanics of materials. A bibliography and chronological tables complete the text.

HOW TO PREPARE AND MAINTAIN A SUPERVISORS' POLICY MANUAL. (Research Report Number 11.) American Management Association, 330 West 42d Street, New York, N. Y., 1947. 71 pages, illustration, tables, $8^3/_4$ by 6 inches, paper, $3. Based on a survey of company practices, this volume deals, for the most part, with the actual techniques of collecting and appraising source material, writing the policies and procedures, coding and indexing them, and revising the manual as new material and changes develop. Both advantages and disadvantages of various procedures are reported.

PAMPHLETS . . .

Brochure on Brines. "Calcium Chloride and Sodium Chloride Refrigeration Brines." A brochure issued by the American Society of Refrigerating Engineers which presents in nontechnical language the properties, preparation, and corrosion characteristics of the two widely used brines. It is designated Application Data 40, and may be obtained from the American Society of Refrigerating Engineers headquarters, 40 West 40th Street, New York, N. Y., at 30 cents a copy.

3M Adhesives in Industry. Research help for industrial customers, in choosing the right adhesives, sealers, and coatings, is offered in a brochure by Minnesota Mining and Manufacturing Company, St. Paul 6, Minn. The 28-page brochure contains 40 pictures, cites 18 case histories, and lists 26 of the more than 1,000 formulas offered by the company's adhesives and coatings division in Detroit. Copies are available on request to the firm's offices at 901 Fauquier Avenue, St. Paul 6, Minn.

American Standard Specification for Dry Cells and Batteries. The fifth edition of the "American Standard Specification for Dry Cells and Batteries," approved by the American Standards Association, is available as Circular C466 of the National Bureau of Standards. The new specification, to be known as American Standard C18-1947, covers the first-grade product of manufacturers and includes all the types of batteries commonly used by the public. Its technical requirements also have been incorporated into a revision of Federal Specification W-B-101. Circular 466 may be obtained for ten cents from the Superintendent of Documents, Washington 25, D. C., or from the American Standards Association, 70 East 45th Street, New York, N. Y.

Basic Radio Propagation Predictions. For June 1948, three months in advance. CRPL-Series D. Number 42. A National Bureau of Standards publication which is available from the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C. Ten cents.

HIGHLIGHTS........

Index. The 1947 index to *ELECTRICAL ENGINEERING* is being distributed with this issue as Section II. This index includes a listing of 1947 technical program papers which were published in *ELECTRICAL ENGINEERING* either in abstract or more extended form.

Winter Meeting. More than 50 sessions including some 170 papers are scheduled for the winter general meeting program at Pittsburgh, Pa. (*pages 90–2*). A number of interesting inspection trips have been planned also (*page 89*).

AIEE PROCEEDINGS. An order form for AIEE *PROCEEDINGS* listing the available technical program papers presented at the Pacific general, Middle Eastern District, and the Midwest general meetings was published last month (*EE, Dec '47, pp 55A and 56A*).

AIEE Standards. Prices for AIEE Standards have been revised as of January 1, 1948 (*page 97 and page 36A*).

AIEE Subcommittees. A few months ago an outline of the new AIEE committee structure (*EE, Oct '47, pp 1006–11*) and the officers and committee list for 1947–48 (*EE, Oct '47, pp 1031–35*) was published. A listing of the subcommittees of the power group, including scopes, projects, and personnel, appears in this issue (*pages 106–09*).

Mexico City. The AIEE summer meeting, which will be held June 21–25, 1948, in the city of Mexico, Mexico, will afford unusual opportunities to combine business and pleasure (*page 97*). Detailed information is scheduled for the February issue.

Electron Tube Conference. Something new in an AIEE meeting, exemplifying the new and broader AIEE meeting program, is the electron tube conference, March 29–31, 1948 (*page 96*).

The Engineer and Nuclear Physics. The second article of the series developed by the AIEE nucleonics committee discusses the relation between mass and energy and its influence on the engineering world. The series, as a whole, will constitute an authoritative textbook and reference providing an up-to-date perspective of the several phases of atomic research and nuclear theory (*pages 1–5*).

Engineering in Europe. An engineer recently returned from a visit to Europe observes that European engineers today are interested in much the same problems as engineers in the United States. However, technical progress, though fairly good, is hampered seriously by disturbed economic conditions and shortages (*pages 13–19*).

Employer Practice. With this publication of supplementary data to the report on "Employer Practice Regarding Engineering Graduates" which appeared in April 1947, the scope of the original survey has been enlarged to include returns from 125 co-operating employers who employ a total of 38,000 engineers (*pages 53–7*).

1947 Developments. Each year brings new engineering developments that make for progress in the art, and 1947 was no exception. A picture survey reflecting some of these significant engineering developments appears in this issue (*pages 22–31*).

Sign of Reactive Power Recommended Changed. By arbitrary definition inductive reactive power is considered negative. However, in a great number of industrial applications it has proved more advantageous to consider it positive. The subcommittee on reactive power of the AIEE Standards committee recommended, in view of these facts, that the sign of reactive power be changed (*EE, Nov '46, pp 412–16*). Having considered the discussions which followed, the subcommittee has prepared a closing discussion in which it sustains its previous recommendation (*pages 49–53*).

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Electronics Comes of Age. Based on 50 years of development initiated by the discovery of the electron, electronics comes of age as a science and industry of unlimited potentialities "if it meets its responsibilities for constant self-renewal and for the creative vision, enterprise, and initiative which always have characterized American industry" (*pages 32–7*).

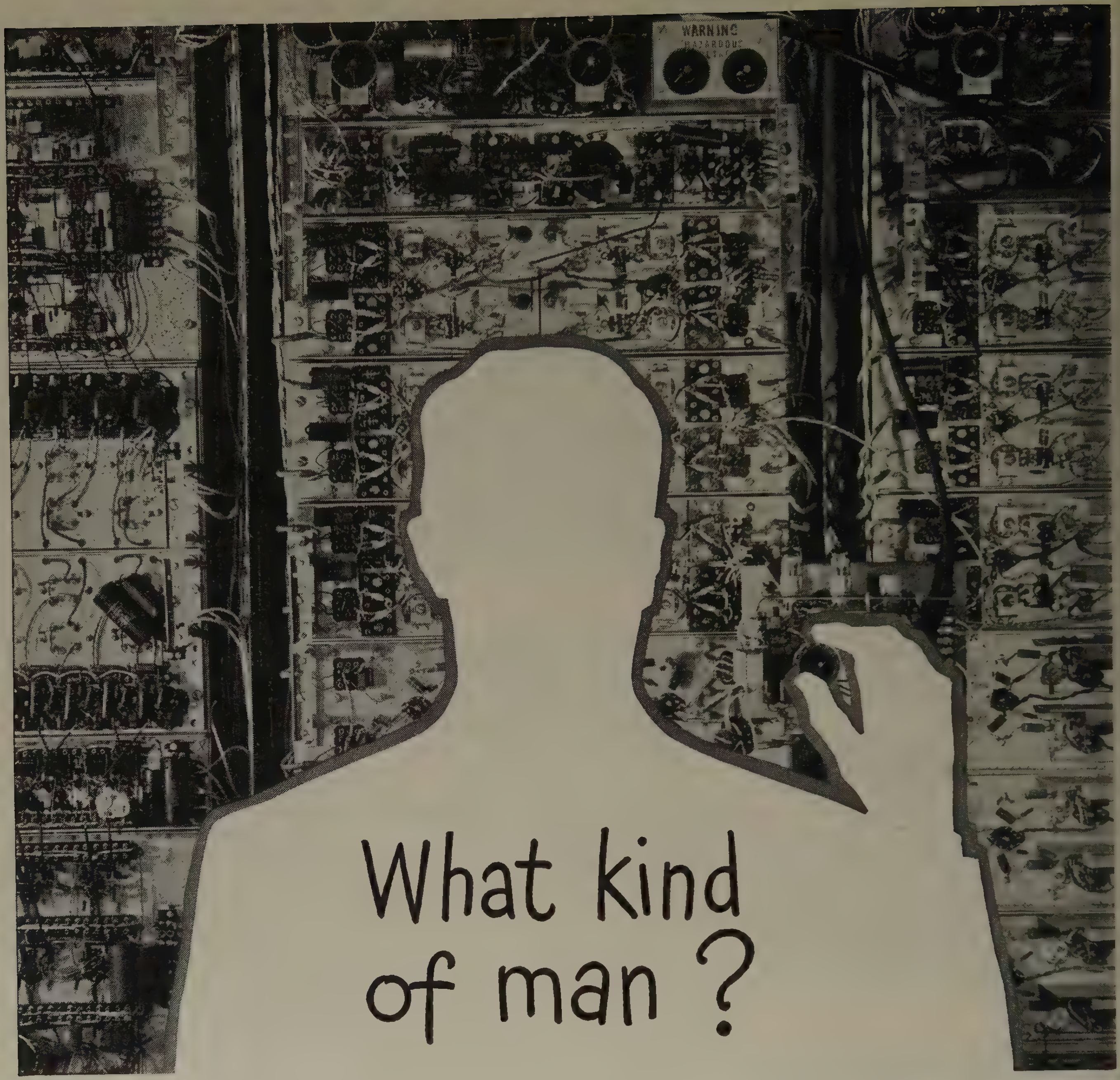
Voltage Notations Should Be Standardized. Four different conventions are accepted generally for designating the polarity or "direction" of voltages and potential differences. A critical analysis of the discrepancies and a proposal for standardization are offered (*pages 41–8*).

Electronic Calculators. The automatic electronic computer, the present product of the evolution of calculating machines, will eliminate the drudgery from long detailed repetitious calculations and leave the technical men with time to continue their research. Many additional services may be supplied to the general public by organizations hitherto hampered by the time involved in calculations (*pages 6–12*).

Power Generation Development Reviewed. During the period 1940–46 many changes were effected in power plant practice. New equipment and refined models of previous types appeared. World War II necessitated many revisions of long-standing customs (*pages 59–75*).

Corrections. In the tabulation of "Sections" of the list of officers and committees for 1948 (*EE, Oct '47, p 1035*) the Arkansas Section was designated incorrectly in District 4. The Arkansas Section is, of course, in District 7. A correction also should be made in the book review, "Mathematical Tables from the Handbook of Chemistry and Physics," which appeared in the November issue (*EE, Nov '47, p 1163*). The book was priced incorrectly at $1 per copy. The correct price is $1.25 for the pocket-size edition and $1.75 for the desk-size edition. Lastly, on page 1223 of the digests of National Electronics Conference papers which were published in the December issue, the first paragraph under the subheading "Computers" gives the location of the Electronic Control Company as Detroit, Mich. The proper address of this company is Philadelphia, Pa.

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices 500 Fifth Avenue, New York 18, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. &. L R. Act of February 28, 1925. January 1948, Vol. 67, No. 1. Number of copies of this issue *43,000*



WHAT KIND of men are the 2,300 scientists and engineers of Bell Telephone Laboratories?

Men of many types, working in different fields of research, may contribute to each development.

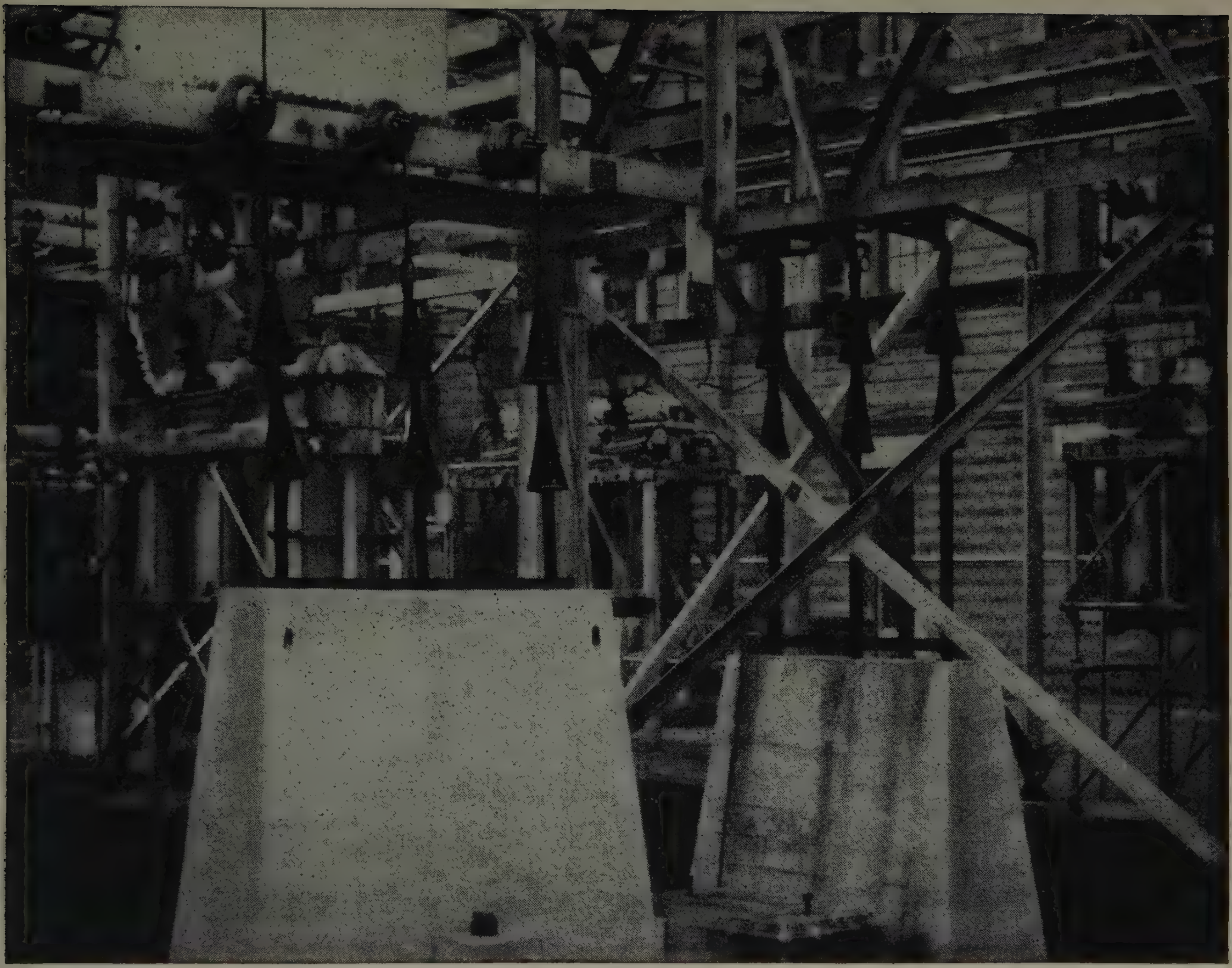
But all have certain characteristics in common: Good minds as a foundation, many years of learning in the fundamentals of their science and the methods of research, and a co-operative attitude — for without co-operation of individuals these products of research could never be produced.

Above all else, however, they have "the spirit to adventure, the wit to question, and the wisdom to accept and use."

That kind of men can produce the finest telephone equipment in the world — and have done so.

BELL TELEPHONE LABORATORIES

EXPLORING AND INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE



Insulated with Kerite—Operating at 22 kv.

THIS 22-kv Kerite insulated cable has been in service since 1934 without interruption. It is electrically and mechanically protected by conducting asbestos braid. Its terminal design is simple and direct.

Kerite cable—ideal for the job—differs from other cable in that it is the only cable protected by the time-tested Kerite manufacturing process using the original Kerite formula developed nearly a century ago. Kerite insulation is in service today that was made before 1890! All of its electrical properties are still excellent.

Kerite insulated wire and cable is available in many forms and for many purposes—low or high voltage, indoor, outdoor, aerial, or submarine. Ask any Kerite user about its stamina and low cost per year. *The Kerite Company, 30 Church Street, New York, N. Y.*

Offices also at: 122 S. Michigan Avenue, Chicago 3; 582 Market Street, San Francisco 4; 714 W. Olympic Blvd., Los Angeles 15.

Kerite Insulation—Your Cable's Best Life Insurance

DAYS KERITE

KERITE CABLE

INDUSTRIAL NOTES . . . .

Plant Expansion Completed. S & C Electric Company, Chicago, Ill., formerly Schweitzer and Conrad, Inc., has completed its plant expansion move. Increasing present floor area by 40 per cent, the expansion at this time consists of the leasing of another manufacturing building in the neighborhood, to be known as plant number 2, for the manufacture of distribution primary cutouts, and a considerable increase in storage facilities at plant number 1.

New Appointment. Ray C. Sanborn has been appointed manufacturing planning engineer for the General Electric wire and cable division, Bridgeport, Conn. He will be responsible for all planning activities within the division.

Sales Director. Clyde A. Sluhan has been appointed manager of industrial sales for the Anderson Oil Company, Portland, Conn. He will direct the sales in the company's new expansion program.

Regional Manager. William G. Haas has been appointed Great Lakes regional sales manager, Crosley division, Avco Manufacturing Corporation, Cincinnati, Ohio.

Personnel Director. Joseph C. Folsom has joined Raytheon Manufacturing Company's subsidiary, Belmont Radio Corporation, Chicago, Ill., as director of personnel and labor relations.

Institute President. C. D. Clawson, president of Ferro Enamel Corporation, was named president of the Porcelain Enamel Institute at the PEI 16th annual meeting, held recently at the Hotel Cleveland, Cleveland, Ohio.

New Post. Former Brigadier-General H. Joseph Lawes, recently retired from the United States Army, has accepted the newly created post of special assistant to the president of the Proctor Electric Company, Philadelphia, Pa.

Trackless Trolleys. The Winnipeg Electric Company, Winnipeg, Manitoba, Canada, has announced that since 1938 buses and streetcars on seven lines in this city have been replaced by electric trackless trolleys.

Purchase Completed. Syntron Company, Homer City, Pa., has purchased the former H. K. Porter Company shell plant at Blairsville, Pa., 12 miles from Homer City. The company's general offices and headquarters will remain at the Homer City plant.

New Appointments. G. L. Hartman has been appointed general sales manager of Belmont Radio Corporation, Chicago, Ill., subsidiary of Raytheon Manufacturing Company.

Moved. Haydon Manufacturing Company, makers of electric timing motors, has moved its offices and manufacturing facilities from Forestville, Conn., to Torrington, Conn.

Committee Election. Jack Clarke, assistant to the president of Lion Oil Company, El Dorado, Ark., has been elected to the oil industry's public relations operating committee.

Opening. Rockbestos Products Corporation has opened a Los Angeles district sales office to serve its wire and cable customers in the southern California territory. It is located at 6919 San Fernando Road, Glendale 1, Calif.

Executive Assistant. Kellen Wiles has been appointed executive assistant to G. C. Derry, general manager of the Sturtevant Division of the Westinghouse Electric Corporation, Hyde Park, Mass.

Named Manager. Roger H. Martin has been appointed manager of the industrial department of the Sturtevant Division of the Westinghouse Electric Corporation, Pittsburgh, Pa.

New Acquisition. The I-T-E Circuit Breaker Company, Philadelphia, Pa., an-

(*Continued on page 18A*)

2-inch wattmeter. . . .

(Electrodynamometer Type)

Another Simpson First. . . .

. . . for discriminating users of fine panel instruments

(ACTUAL SIZE)
Also available in various sizes and case styles. For complete information write for bulletin.

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INSTRUMENTS THAT STAY ACCURATE
ELECTRIC COMPANY 5200-5218 West Kinzie Street, Chicago 44, Illinois
In Canada, Bach-Simpson Ltd., London, Ont.

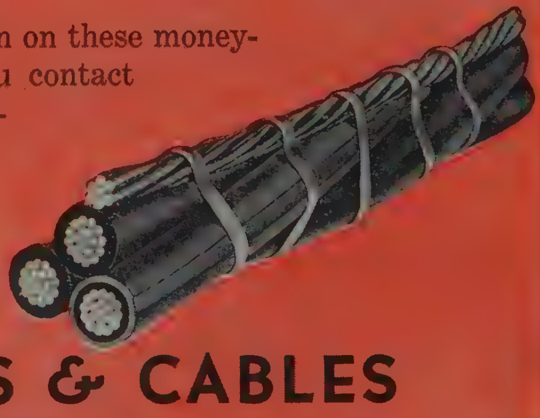
DON'T GO AROUND.... GO THROUGH

Many municipalities will not allow high voltage, open-wire lines to run through settled areas. To overcome this trouble many distribution engineers run their power lines around a town.

This practice is expensive — in poles, in line hardware, in right-of-way, and in wire. We suggest that you cut down this expense by installing Simplex Self-Supporting Aerial Cables. Because these cables are insulated, municipal authorities consider them safe to run through settled areas. Of course the saving in running a pole line through a settled community, instead of around it, is quite evident.

Simplex Self-Supporting Aerial Cables are made in many different constructions to meet the needs of the locality where they are installed. One of the most popular types is made up of one or more individually insulated and jacketed conductors bound to a properly selected messenger. Individual conductors can have the phase markings molded onto the neoprene jackets at three-foot intervals to facilitate identification for tapping.

For further information on these money-saving cables we suggest you contact the nearest Simplex representative or write direct to Cambridge.



SIMPLEX WIRES & CABLES

SIMPLEX WIRE & CABLE CO., 79 SIDNEY ST., CAMBRIDGE 39, MASS.

Silicone News

DC
SILICONES

Longer Life for Generators

Before Silicone insulation was introduced by Dow Corning, electrical engineers had only one alternative when electric machines failed repeatedly because of overloads. They had to make room for a larger motor or generator regardless of how much it might cost. Silicone insulation offers a new alternative which is equally effective and much cheaper.

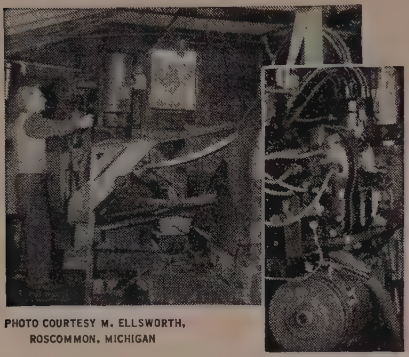


PHOTO COURTESY M. ELLSWORTH, ROSCOMMON, MICHIGAN

The auxiliary and starting loads of the 180 H.P. stationary gasoline engine which drives the hydraulic dredge shown above, require that the generator supply 25 amps at 12 volts to keep the battery charged. The generator had a rating of 17 amps at 12 volts. Such heavy overloading caused Class "A" insulated armatures to fail after two to five days of service. The dredge owner decided to try a Silicone rewind job. Rewound with Silicone insulation by the Chippewa Electric and Marine Company, of Midland, Michigan, the armature is still in service after five weeks of operation. That's seven times as long as the maximum service given by Class "A" insulated armatures—and it cost only three dollars more than a Class "A" job.

Silicone insulation will give the same kind of service in truck, bus, taxicab and aircraft generators. Chippewa has proved this, and now guarantees six months service for Silicone insulated armatures compared to the sixty day guarantee for ordinary armatures. Prospects are that Silicone insulated armatures can be made to last as long as the commutators.

We introduced Silicone insulation over four years ago. We have proved that Silicone insulation has at least ten times the service life and ten times the wet insulation resistance of Class "B" insulation under similar conditions. Specifications for Silicone insulated motors are given in Data Sheet No. A19-3.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
New York • Chicago • Cleveland • Los Angeles
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

(Continued from page 14A)

nounces the acquisition of the Railway and Industrial Engineering Company, Greensburg, Pa.

Public Relations Office. John K. West has been elected vice-president in charge of public relations for the RCA Victor division of the Radio Corporation of America, Camden, N. J.

Board Chairman. Reeve Hoover has been elected chairman of the board of directors of Commercialores, Inc., Washington, D. C. Commercialores was developed recently for the purpose of developing a kyanite deposit in South Carolina.

Acquisition. Economy Pumps, Inc., Hamilton, Ohio, has acquired from the War Assets Corporation the wartime addition to its plant, built by the Defense Plant Corporation. The building was built in 1942 at a cost of $705,000, to house an Economy subsidiary, Liberty Planers, Inc.

New Sales Manager. Following his recent election to the board of directors of the company, Eric E. DeMarsh has been appointed sales manager for Burndy Engineering Company, Inc., New York, N. Y., and Vernon, Calif.

Price Reduction. International Nickel Company, Inc., New York, N. Y., has announced a reduction of $1^{1}/_{4}$ cents per pound in the company's price for refined nickel in the United States. The reduction is effective January 1, 1948.

New Director. Captain L. B. Blaylock, United States Navy (retired), who recently joined the Federal Telephone and Radio Corporation, Clifton, N. J., has been appointed director of the radio division.

Plant Expansion. Leeds and Northrup, Philadelphia, Pa., has purchased a 2-story-and-basement building at 34 East Logan Street, Philadelphia, Pa., one block from its main plant.

Technical Staff Appointment. Arthur Sprague Osborn, Kansas City, Mo., has been appointed to the technical staff of the Midwest Research Institute, Kansas City.

Marshall B. Ross Dies. Marshall B. Ross, manager of the heating device and fan divisions of the General Electric Company's appliance and merchandise department, Bridgeport, Conn., died November 13. He was 41.

Lists Buying Agencies. A revised list of the buying agencies of foreign governments in the United States, covering changes up to the end of October, has been issued by *World's Business* and *Guide*, export business publications, and may be obtained from their offices at 440 Fourth Avenue, New York.

New Appointments. Frank R. Kohnstamm, formerly with Westinghouse Corporation Inc., Cleveland and Mansfield, Ohio, has joined the staff of Jack and Heintz Precision Industries, Inc., Cleveland, as general sales manager. Albert

(Continued on page 32A)

MEASUREMENTS CORPORATION
Model 59

MEGACYCLE METER

Radio's newest, multi-purpose instrument consisting of a grid-dip oscillator connected to its power supply by a flexible cord.

Check these applications:

- For determining the resonant frequency of tuned circuits, antennas, transmission lines, by-pass condensers, chokes, coils.
- For measuring capacitance, inductance, Q, mutual inductance.
- For preliminary tracking and alignment of receivers.
- As an auxiliary signal generator; modulated or unmodulated.
- For antenna tuning and transmitter neutralizing, power off.
- For locating parasitic circuits and spurious resonances.
- As a low sensitivity receiver for signal tracing.

MANUFACTURERS OF
Standard Signal Generators
Pulse Generators
FM Signal Generators
Square Wave Generators
Vacuum Tube Voltmeters
UHF Radio Noise & Field Strength Meters
Capacity Bridges
Megohm Meters
Phase Sequence Indicators
Television and FM Test Equipment

SPECIFICATIONS:
Power Unit: 5⅛" wide; 6⅛" high; 7½" deep. Oscillator Unit: 3¾" diameter; 2" deep.

FREQUENCY:
2.2 mc. to 400 mc.; seven plug-in coils.

MODULATION:
CW or 120 cycles; or external.

POWER SUPPLY:
110-120 volts, 50-60 cycles; 20 watts.

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY

After 28 Years!

Ohio Brass

MANSFIELD, OHIO

Canadian Ohio Brass Co., Ltd., Niagara Falls, Ontario

2870-H

PREFERENCE

(*Continued from page 18A*)

A. Ricker, vice-president in charge of finance, has been appointed to the newly-created position of assistant to the president of the company.

Control Sales. Harry A. Wright has been named engineer-in-charge of control sales of the control section of the electrical department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

NEW PRODUCTS • • • •

High Voltage Ignitron. The tube division of the General Electric Company electronics department, Schenectady, N. Y., has developed a new ignitron tube, type *GL-5630*, for radio transmitter and power rectification application. The tube is suitable for applications which require up to 3,000 kw of d-c power, and features a control grid which times current to a microsecond and gives the tube its voltage-regulating and circuit-breaker qualities. A special potential-dividing grid lowers the voltage gradient between the anode and cathode. Peak voltage of the tube, forward or inverse, is 20,000 volts. Peak current is 200 amperes and average current is 50 amperes.

Signal Tracer. The Feiler Engineering Company, 422 South Dearborn Street, Chicago 5, Ill., has announced a model *DS-5* "pocket stethoscope" which will trace a signal through a radio or other electronic devices when its sensitive probe is touched to key points of the circuits. The instrument is $4^{1}/_{8}$ by $2^{3}/_{8}$ by $8^{3}/_{4}$ inches, and weighs $3^{1}/_{2}$ pounds complete. Any standard type volt-ohm-milliammeter may be plugged into convenient jacks to make an effective radio-frequency vacuum-tube voltmeter. The instrument operates on 115-volt alternating current and gives indication through its own permanent magnet speaker or through headphones which may be plugged in.

Distortion Meter. A Wien bridge null balance included in a feedback amplifier in combination with a sensitive vacuum tube voltmeter and accurately calibrated attenuator comprises model 400 distortion meter made by Barker and Williamson, Inc., 237 Fairfield Avenue, Upper Darby, Pa. The meter is used for measuring low-level audio-frequency voltages and for determining their noise and harmonic content. It also may be used in measuring frequency and gain characteristics of audio-frequency amplifiers or for any other application where a vacuum tube voltmeter is required in the audio-frequency range. A variable frequency selective filter provides a single frequency suppression circuit for the frequency range of 50 to 15.000 cycles, per second.

WANTED

Copies of the May and June 1947 issues of *ELECTRICAL ENGINEERING*. Please mail (parcel post) to American Institute of Electrical Engineers, 33 W. 39th St., New York 18, N. Y., printing your name and address upon the enclosed wrapper. Twenty-five cents, plus postage, will be paid for each copy returned.

TRADE LITERATURE

Germicidal Lamps. Booklet, 8 pp. Released to General Electric lamp dealers, "Sanitation on the Farm With G-E Germicidal Lamps" illustrates in non-technical terms the recommended techniques employed in killing air-borne bacteria in barns, stables, and poultry houses through the use of germicidal lamps in upper air radiation units. Lamp Department, General Electric Company, Nela Park, Cleveland 12, Ohio.

Hard Overlay Welding. Bulletin, 8 pp. Describes specific procedures involved in industrial equipment salvage welding with various gas and arc rods for producing hard overlay at low temperature. "The Eutectic Welder; Overlay Issue." Eutectic Welding Alloys Corporation, 40 Worth Street, New York 13, N. Y.

(*Continued on page 38A*)

THE MERCOID CORPORATION
4223 West Belmont Avenue, Chicago 41, Illinois

MANUFACTURERS OF AUTOMATIC CONTROLS FOR HEATING, AIR CONDITIONING, REFRIGERATION AND NUMEROUS INDUSTRIAL APPLICATIONS. ALSO MERCOID BRAND MERCURY SWITCHES.

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See catalog No. 600 for description of complete line.

DA PRESSURE CONTROLS
Industries' first choice for dependable control performance. The outside adjustment and visible dial eliminate all guesswork when setting the operating range.

TEMPERATURE CONTROLS
Used on a variety of industrial temperature applications. Have same adjustment feature described above.

MERCOID RELAYS
Recommended wherever quiet and dependable performance are essential. Various types available.

MERCURY SWITCHES
Mercoid brand switches are noted for their superior operating qualities. Various types available.

LIQUID LEVEL CONTROLS
Available for gasoline, oil, ammonia or other low specific gravity liquids. Also for liquids at high pressures.

MERCOID FLOAT CONTROLS
Used for maintaining fluid levels in tanks or for control of sump pumps, etc. Two types, the counter-balance type and plunger type available.

All Mercoid Controls are equipped exclusively with mercury switches—assuring better control performance and longer control life.

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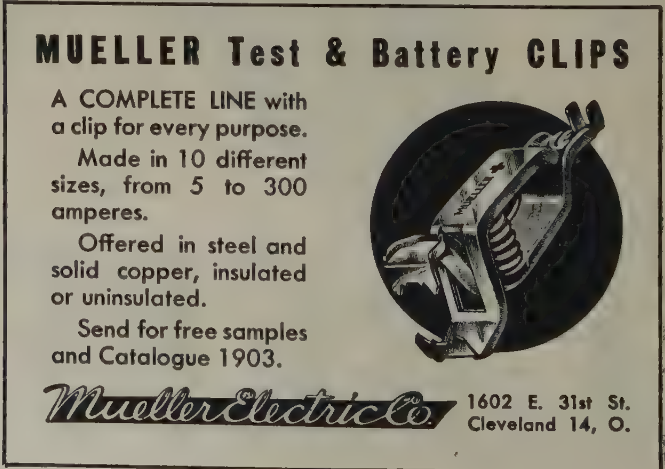

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Resist atmospheric surface action while retaining constant and reproducible contact resistance.

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Operate as a sliding contact on commutators and slip rings.

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Resist the action of most corrosive gases and chemicals.

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(*Continued from page 32A*)

Digest. Catalogue, 76 pp. New Square D digest serves as a source of reference and information on Square D equipment manufactured by the switch and panel, and the industrial controller division. It includes size, capacity, and dimensional data, together with current prices. Also included in this condensed catalogue are tables for reference in proper selection of devices. Square D Company, 6060 Rivard Street, Detroit 11, Mich.

Ni-Resist. Booklet, 36 pp. Gives detailed information on the physical and mechanical properties of this widely used cast nickel alloy. Performance under a wide variety of industrial conditions involving corrosion, heat, and wear is described. "Engineering Properties and Applications of Ni-Resist." The International Nickel Co., Inc., 67 Wall Street, New York 5, N. Y.

Electrical Laminations Handbook. Booklet, 16 pp. Contains complete information on Thomas and Skinner stock lamination dies, data on weights, characteristics, and suggested applications of electrical steels. A section is given to oriented steels and thin steels with a table of data on core loss for very thin steel. Thomas and Skinner Steel Products Company, 1126 East 23 Street, Indianapolis, Ind. Catalogue Number 47.

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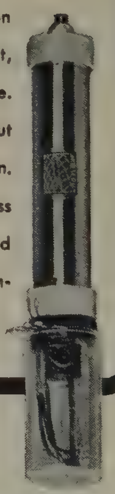

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HIGHLIGHTS........

AIEE Special Publications. From time to time several articles or technical papers are grouped together and published as a single pamphlet. Two such pamphlets recently have been made available: "Tidd 500-Kv Test Project," and "Electric Power in the Pulp and Paper Industry." A list of all the special publications available appears in the advertising section of this issue (*page 48A*).

AIEE Meetings. Many Institute members and their families will be enjoying their vacations in Mexico this summer while attending the AIEE summer general meeting in Mexico City. General information regarding transportation, hotels, rate of exchange, and customs regulations appears in this issue (*pages 190–2*). Detailed information on any phase of the trip may be obtained by sending in the "request-for-information coupon" which appears in the advertising section (*page 54A*).

AIEE Conferences. The new type of AIEE national meeting known as the AIEE conference will make its debut late in March with the AIEE conference on electron tubes for instrumentation and industrial use. Objectives and organization of the conference-type meeting, and tentative program plans for this first conference, are covered in this issue (*page 189*).

AIEE Subcommittees. The subcommittees of the industry group, communications and science group, and the general applications group substantially completes the listing of the AIEE technical subcommittees (*pages 203–06*).

The Patent Question. Does patent consciousness interfere with co-operation between industrial and university research laboratories? The views expressed in this article on support a negative reply to this highly controversial question for, says the author, with its present patent system the United States has achieved "the greatest fertility in invention and the greatest industrial progress the world yet has seen" (*pages 135–6*).

The ENIAC. Computers have many different properties which make different types suitable for different operations. The electronic large-scale general-purpose digital type (of which the ENIAC is the only example now in operation) is completely flexible within the limits of its programming capacity. It can handle virtually any type of practical problem requiring numerical solution (within the limitations set by the capacity of certain components), but is economical only for problems which involve repetitious computations of the same type or an excess number of man-hours of numerical calculations (*pages 163–72*).

Nuclear Reactions Outlined. The third article of the series developed by the AIEE nucleonics committee describes the various varieties of nuclear reactions made possible by development of high-voltage accelerating devices. Much is still unknown about the "why's and wherefore's" of nucleonics, but great strides have been made toward complete comprehension of the forces and masses that exist within the nucleus shell. The series, as a whole, will provide an authoritative understanding of this rapidly developing scientific field (*pages 125–34*).

High-Voltage Measurement. "A simple method for accurately measuring voltages present on high-voltage systems during both transient and steady-state conditions without modifying the conditions producing the voltage to be measured has been developed" (*pages 154–7*).

Magnetic Sound on Film. The magnetic sound system has advantages in the recording, editing, and arranging of 35-millimeter professional productions. It is also especially well suited for 16-millimeter and 8-millimeter films, allowing the amateur to make sound pictures with simple inexpensive equipment (*pages 136–41*).

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China Plans Reconstruction. Faced with the almost impossible task of rebuilding and expanding the electrical utilities of China, the National Resources Commission has launched both a short-time alleviation program and a long-run building plan. Both are dependent upon use of Japanese reparations and foreign aid (*pages 146–9*).

Leakage Reactance Discussed. The causes and effects of leakage flux in electric equipment long have been recognized. Methods of analysis and calculation are still topics for open debate. Textbooks often separate discussions of leakage reactance by chapters on various equipment. This simple nonmathematical article gives an over-all view of leakage reactance as it exists in transformers, induction motors, synchronous machines, and d-c machines (*pages 142–6*).

Vibration Problems. A record of four typical types of balance problems as encountered in the field serves to broaden the engineers' knowledge of actual situations and to show the part that experience plays in the solutions of the problems (*pages 150–3*).

A-C Potentiometer. Although the value of the d-c potentiometer in the field of d-c measurements is well known, the a-c potentiometer has not enjoyed comparable popularity in the field of a-c measurements, possibly because the a-c bridge has provided a means of making measurements where indicating instruments were not suitable. However, the potentiometer almost always excels in the measurement of voltage and current, and generally has a more universal application than the bridge (*pages 173–81*).

Rubber Industry Uses Electronic Developments. Electronic controls have been applied to various co-ordinated drive systems in the rubber industry. Some unique applications have been developed, but most of the system can be adapted for other industrial applications. Three typical examples are discussed (*pages 119–24* and *188*).

Echo Testing. Supersonic waves can be used in testing for defects in metal parts as a complement to X-ray testing. A crystal is used to transform electric pulses into high-frequency sound wave and to detect echo pulses (*pages 181–5*).

Correction. In J. J. Smith's article "The Atom and Its Nucleus" (*EE, Dec '47, pp 1165–75*) the diameter of a heavy nucleus erroneously was stated to be approximately 10^{-2} centimeter. Actually the diameter is about 10^{-12} centimeter (*page 214*).

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices 500 Fifth Avenue, New York 18, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925. February 1948, Vol. 67, No. 2. Number of copies of this issue 43,800

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A. G. de Wolfe "brought to practical perfection a machine for insulating all kinds of telegraph wires," said his obituary in 1896. And at the time of his invention, the telegraph industry was the only industry requiring insulated wire.

It was Mr. de Wolfe's mechanical genius that made possible the application of A. G. Day's remarkable invention of Kerite insulation, for at the time Mr. Day produced Kerite, no suitable means of applying it to wire existed.

Down through the years, Kerite engineers have kept on working for new and better things. And they have contributed many advances to the art of cable making. But one thing has never changed:

> **The Kerite insulation of today is still based on the original Kerite, which has always been the secret of Kerite's long life and low cost per year.**

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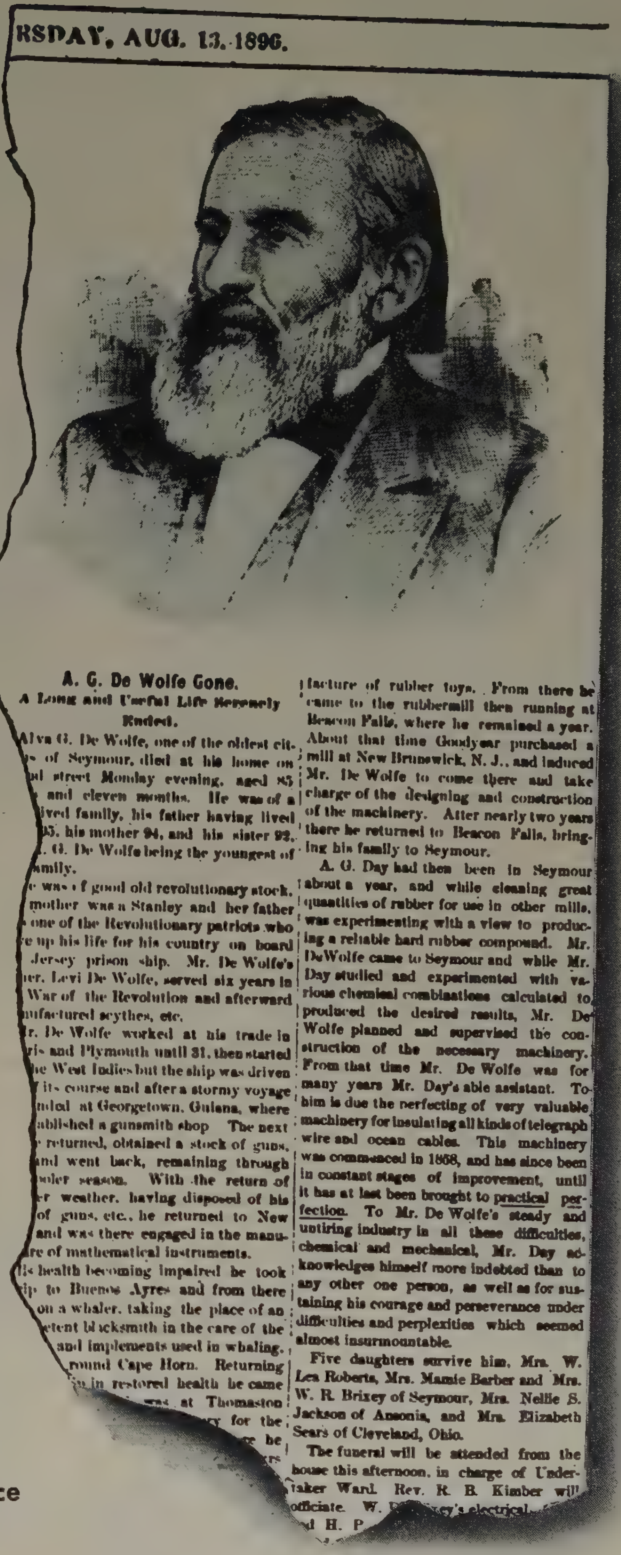

RSDAY, AUG. 13, 1896.

A. G. De Wolfe Gone.

A Long and Useful Life Serenely Ended.

lva G. De Wolfe, one of the oldest cit-
s of Seymour, died at his home on
l street Monday evening, aged 83
and eleven months. He was of a
ived family, his father having lived
5, his mother 94, and his sister 92,
. G. De Wolfe being the youngest of
amily.
e was of good old revolutionary stock.
mother was a Stanley and her father
one of the Revolutionary patriots who
e up his life for his country on board
Jersey prison ship. Mr. De Wolfe's
er, Levi De Wolfe, served six years in
War of the Revolution and afterward
ufactured scythes, etc.
r. De Wolfe worked at his trade in
is and Plymouth until 31, then started
he West Indies but the ship was driven
its course and after a stormy voyage
nded at Georgetown, Guiana, where
ablished a gunsmith shop The next
returned, obtained a stock of guns,
and went back, remaining through
oler season. With the return of
r weather, having disposed of his
of guns, etc., he returned to New
and was there engaged in the manu-
re of mathematical instruments.
is health becoming impaired he took
ip to Buenos Ayres and from there
on a whaler, taking the place of an
etent blacksmith in the care of the
and implements used in whaling.
round Cape Horn. Returning
in restored health he came
was at Thomaston
ry for the
he
rs

facture of rubber toys. From there he came to the rubbermill then running at Beacon Falls, where he remained a year. About that time Goodyear purchased a mill at New Brunswick, N. J., and induced Mr. De Wolfe to come there and take charge of the designing and construction of the machinery. After nearly two years there he returned to Beacon Falls, bringing his family to Seymour.

A. G. Day had then been in Seymour about a year, and while cleaning great quantities of rubber for use in other mills, was experimenting with a view to producing a reliable hard rubber compound. Mr. DeWolfe came to Seymour and while Mr. Day studied and experimented with various chemical combinations calculated to produced the desired results, Mr. De Wolfe planned and supervised the construction of the necessary machinery. From that time Mr. De Wolfe was for many years Mr. Day's able assistant. To him is due the perfecting of very valuable machinery for insulating all kinds of telegraph wire and ocean cables. This machinery was commenced in 1868, and has since been in constant stages of improvement, until it has at last been brought to practical perfection. To Mr. De Wolfe's steady and untiring industry in all these difficulties, chemical and mechanical, Mr. Day acknowledges himself more indebted than to any other one person, as well as for sustaining his courage and perseverance under difficulties and perplexities which seemed almost insurmountable.

Five daughters survive him, Mrs. W. Lea Roberts, Mrs. Mamie Barber and Mrs. W. R. Brixey of Seymour, Mrs. Nellie S. Jackson of Ansonia, and Mrs. Elizabeth Sears of Cleveland, Ohio.

The funeral will be attended from the house this afternoon, in charge of Undertaker Ward. Rev. R. B. Kimber will officiate. W. R. Brixey's electrical
d H. P

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INDUSTRIAL NOTES....

Radio Engineer. Stanley C. Kolanowski has been named chief radio engineer of Stewart-Warner Corporation, Chicago 1, Ill.

GE Appointment. Murray H. Owen has been appointed manager of sales of the General Electric Company's wire and cable division, Bridgeport 2, Conn.

Assistant Manager. C. H. Linder has been named assistant manager of manufacturing for the General Electric Company's apparatus department, Schenectady, N. Y.

Board Election. Charles T. Fisher, Jr., has been elected to the board of directors of The Detroit Edison Company, Detroit, Mich.

Haydon Moves to New Quarters. With the completion of a 3-story addition to its former 2-story quarters in Torrington, Conn., the Haydon Manufacturing Company, producers of timing motors and apparatus, has moved all operations from Forestville, Conn. The company will cease activities in another 2-story building in Torrington which will be occupied by Seth Thomas Clocks, a division of the General Time Instruments Corporation.

CBS Wins Billboard Award. For the ninth consecutive year, the Columbia Broadcasting System's press information department has won *Billboard's* annual radio publicity survey. Results of the magazine's tenth annual poll of the nation's radio editors indicated that the editors voted for CBS as having the best publicity department among the four networks. The National Broadcasting Company placed second, American Broadcasting was third, and Mutual Broadcasting System, fourth.

Worthington Appoints Assistant Managers. Edwin A. Murray and Howard M. Bateler have been appointed assistant managers of the compressor division of Worthington Pump and Machinery Corporation, at Buffalo, N. Y.

Nucleonics Administrator. R. S. Neblett has been named administrator of General Electric's nucleonics project, which consists of work on atomic energy for the United States Energy Commission.

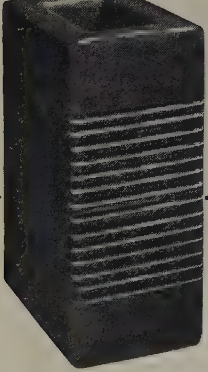
Automatic Controls. A new company in the field of automatic controls, known as Robertshaw-Fulton Controls Company, has been formed through the merger of Robertshaw Thermostat Company, Youngwood, Pa.; Fulton Syphon Company, Knoxville, Tenn.; and Bridgeport Thermostat Company, Bridgeport, Conn. The organization of the company culminates a series of mergers combining five long established companies, each a wholly owned subsidiary of Reynolds Metals Company. The two others included in addition to those merged yesterday, are the American Thermometer Company, St. Louis, Mo., and Grayson Heat Control, Ltd., Lynwood, Calif.

Kodak Technical Aid. Doctor Emmett K. Carver has been appointed to the position of technical assistant to the general manager of the Kodak Park plant in Rochester, N. Y.

Scott Heads New Company. H. H. Scott, inventor of the Dynamic Noise Suppressor, has announced the formation of a new organization known as Hermon Hosmer Scott, Inc., of which he will be president and director of engineering. Henry Chrystie will be vice-president and Ralph P. Glover will act as midwestern engineering representative.

Radio Set Statistics. The Radio Manufacturers Association reported that a total of 3,761,271 radio and television receivers were produced by RMA member-companies during the third quarter of 1947, raising the total number of sets of all types produced until that time to 12,371,915.

(*Continued on page 32A*)



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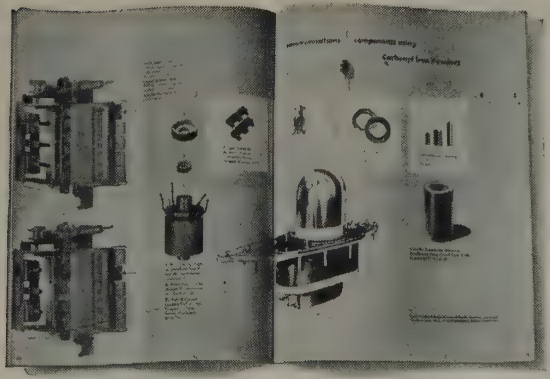

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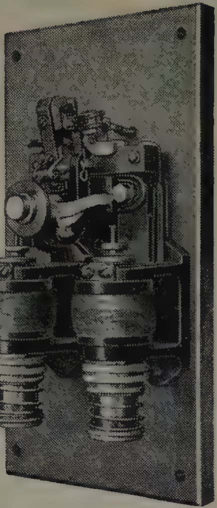
Silicone News

DC SILICONES

DC Silicone Fluid Improves Dashpot Performance



One of several types of precision overload relays made by The Electric Controller and Mfg. Co., Cleveland, Ohio. DC 500 Fluid in the dashpots of these relays, improves their inverse time element characteristics.

Because DC Silicone Fluids are basically different, they have advantages that just don't exist in other known fluids. That makes them worth trying in old and new applications. In many cases, making an improvement is as simple as substituting a DC Silicone Fluid for the liquid already in use. Here's an example of that.

To protect electric motors from overloads, The Electric Controller and Mfg. Co. makes relays of several forms with an inverse time element feature. Such relays permit overloads of short duration, but prevent motor damage from light or heavy sustained overloads. This is accomplished by the damping action of a liquid filled dashpot attached to the relay plunger. A special oil was formerly used, but viscosity variations with temperature changes made close adjustment impractical.

The relatively constant viscosity of DC 500 Fluid over a broad temperature range permits a close relay setting, with adequate delay for high inrush current during the starting period, regardless of temperature. Other advantages given by the relay manufacturer are:

> DC Silicone Fluid does not become gummy. It is resistant to oxidation, acid fumes, and corrosive salt solutions. It is non-volatile, stable to heat, chemically inert, and insoluble in water.

DC Silicone Fluids are available in viscosity grades ranging from 0.65 to 30,000 centistokes. Other Dow Corning Silicone products, all possessing unique and useful properties, include resins, greases, and Silastic*. Silicones have been in commercial production at Dow Corning for nearly five years. Telephone the branch office nearest you for engineering assistance, or write direct for Catalog A 1-7.

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In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

(Continued from page 14A)

Philco Sales Manager. John J. Moran has been appointed sales manager of the accessory division, Philco Corporation, Philadelphia, Pa.

Board Chairman. Byron C. Foy, chairman of the board of Jack and Heintz Precision Industries, Inc., Cleveland, Ohio, has been elected president of the company.

New Export Corporation. Empiria Corporation, 149 Broadway, New York 6, N. Y., has been formed in collaboration with its London colleagues, Empiria Products Ltd. The corporation will export equipment in the electrical, engineering, electronic, and radio fields, as well as component parts.

New Appointment. George F. Devine has been appointed commercial engineer of the specialty division of General Electric Company's electronics department at Syracuse, N. Y.

NEDA President. Jack E. Snyder, assistant general manager of Concord Radio Corporation, has been elected president of the Chicago chapter of the National Electronics Distributors Association.

New Organization. Louis M. Benkert and Paul Duer have announced the formation of Benkert and Duer, Inc. The new

(Continued on page 56A)

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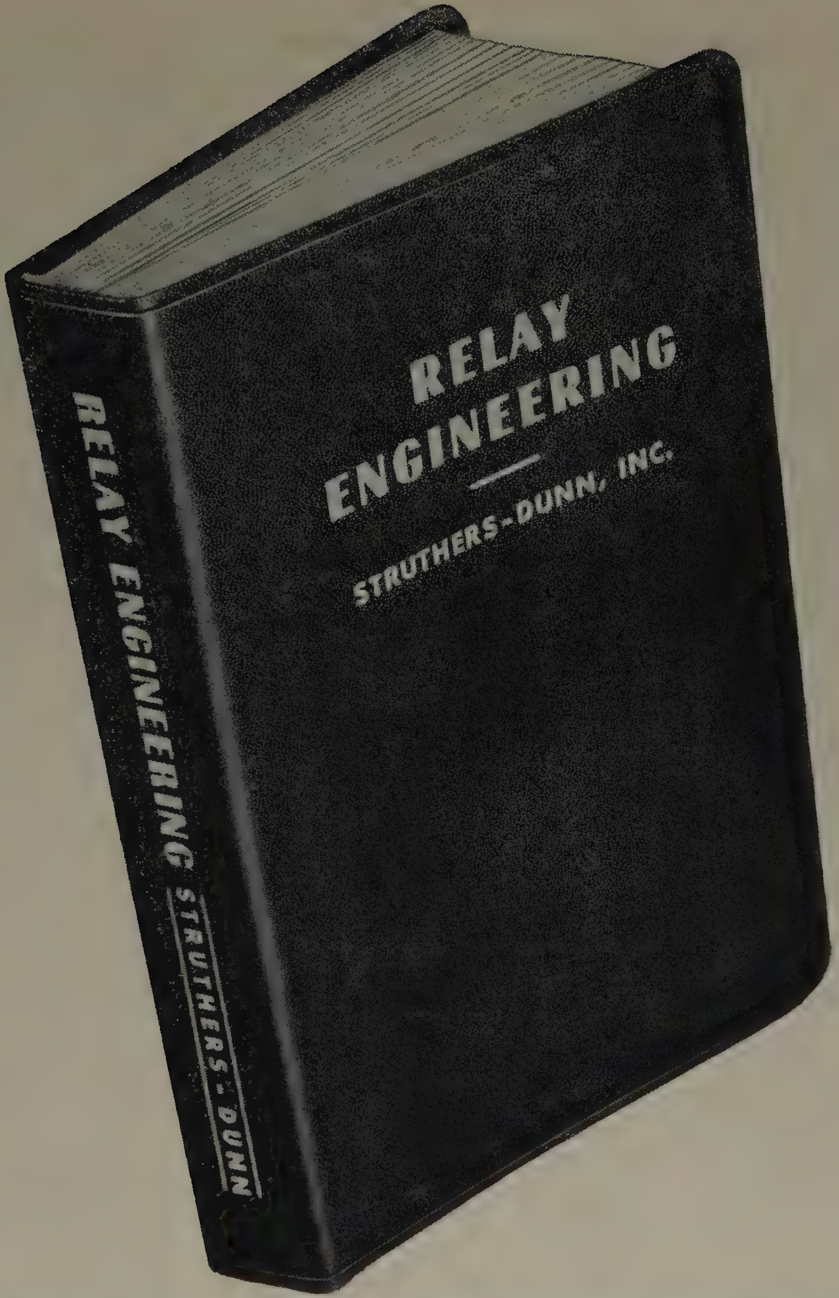

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STRUTHERS-DUNN, INC., 150 N. 13TH ST., PHILADELPHIA 7, PA.

Request for Information

AIEE Summer General Meeting

C. S. Purnell, Chairman
AIEE Special Meeting Committee
33 West 39th Street
New York 18, N. Y.

I am interested in attending the AIEE summer general meeting in Mexico City, June 21–25, 1948, and wish to receive additional information as indicated in the following (I understand I will be placed under no obligation). There may be approximately ...... persons in my party which would leave from ....

- ☐ **Transportation:**
  - ☐ Rail
  - ☐ Air
  - ☐ Automobile
  - ☐ Steamer from Pacific Coast
- ☐ **Side trips:**
  - ☐ En route
  - ☐ From Mexico City
- ☐ **What to see and do in Mexico City**
- ☐ **Other information, specifically** ....

Name..

(Please typewrite or print)

Address..

....

(Continued from page 54A)

months basis. May take graduate work. Extra compensation for Summer teaching. Half time graduate assistants $120 per month. Address: Box 582, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

GRADUATE ELECTRICAL ENGINEER—Experienced in Power Station, Transmission and Distribution design and installation. Permanence and advancement depending upon performance. Applicants should state full details of qualifications, when available and salary expected. Address: Engineering Department, Power Corporation of Canada Limited, 355 St. James St. W., Montreal.

APPLIED PHYSICISTS—ENGINEERS for permanent staff positions with long-established and growing precision instrument company, located in New York City. Experience should be in applied research, development or design, relating to electro-mechanical, electro-magnetic or electronic devices. Address: Box 583, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

WANTED. Graduate Electrical Engineer with experience in design, layout and maintaining electrical equipment and power distribution. Must be able to plan and direct the engineering of electrical work in Plant with 2,300 volt, 5,000 KW generation. Middle Eastern location. Address: Box 584, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

EXCELLENT permanent position for Ph.D. electrical engineer or physicist. High frequency heating experience preferred. Large manufacturer. Write details to Box 585, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

PHYSICS: Southwestern church-related University. Man with master's degree and teaching experience to teach radio theory and electronics. Salary range: $3000–$3300 for 9 months. Address: Box 586, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

POSITION AVAILABLE—Instructor of Electrical Engineering—graduate—Primarily interested in power or power machinery. Some industrial experience required. State qualifications in first letter. Location Cleveland. Start March 1st. Address: Box 587, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ELECTRICAL ENGINEER: To represent instrument firm in Chicago area. Necessary to establish residence in that area. Salary basis. Write, stating education, experience, etc., to Box 588, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

WANTED ELECTRICAL ENGINEERS FOR OFFICE AND FIELD WORK—Large industrial concern has opening for the right man having substantial experience in drafting and field work on primary and secondary systems, power, lighting and substations in industrial plants. State details of education, age, experience and salary required. Location Michigan. Address: Box 589, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

WANTED—Junior, Assistant, and Associate Electrical Engineers with Bachelor's degree required, some radar and electronics experience preferred for positions with progressive Southwestern Research & Development Division. Excellent opportunities for those demonstrating superior abilities. Address: Box 590, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

EXECUTIVES—ENGINEERS of executive caliber: Your personal requirements in negotiations for better positions throughout the nation met via our individual procedures. Strict confidence assured. Write for details. Jepson Executive Service, 247 Porter Bldg., Kansas City 2, Mo.

(Continued from page 32A)

organization will maintain three offices—in Columbus 2, Ohio (4820 Olentangy Boulevard); Cleveland 14, Ohio (859 Leader Building); and Indianapolis, Ind. (325 Bankers Trust Building).

NEW PRODUCTS • • • •

Low-Voltage High-Current Rectifier. Mellaphone Electronic Rectifier Company, Inc., Rochester, N. Y., announces a new line of low-voltage high-current rectifiers for operation from 220 or 440 volts 3-phase a-c power lines. D-c output voltage can be varied from 0 to 6 volts, with a capacity of 600 amperes, or from 0 to 12 volts with a capacity of 300 amperes.

Air-Break Switch. The Hi-Voltage Equipment Company, Cleveland, Ohio, announces a new line of Air-Break Switches, designated type *A-R*. These switches, with current rating of 200 amperes, are manufactured for four voltage capacities: 7,500, 15,000, 23,000, and 34, 500.

Small Welder. A new series of press-type welders has been announced by Sciaky Brothers, Chicago, Ill. Utilizing a standard frame size, these welders offer a choice of five power ratings (20, 30, 40, 50, and 75 kva) and four throat depths (12, 18, 24 and 30 inches). Capacities on mild steel range from 0.016 inch up to 0.125 inch.

High-Fidelity Amplifier. Allied Radio Corporation, Chicago, Ill., has released a newly designed 20-watt photo amplifier that is adapted to high-fidelity reproduction from phonograph records, or amplitude or frequency modulation tuners. The amplifier with tubes is priced at $59.95 net, f.o.b. Chicago.

TRADE LITERATURE

Steam Purifiers. Booklet, 12 pp. Describes steam purification units for the removal of moisture and solids in steam lines. "Cochrane Steam Purifiers." Cochrane Corporation, 17th Street and Allegheny Avenue, Philadelphia 32, Pa.

Hight Voltage Resistors. Bulletin *G-1*,4 pp. Complete specifications and characteristics type *MV* high-voltage resistors, 2 to 90 watts, 8-terminal types. Designed for high voltage applications where high resistance and power are required. International Resistance Company, 401 North Broad Street, Philadelphia, Pa.

RESEARCH ENGINEERS

Opportunities in pilotless aircraft research group, for work in radar, radio, servomechanisms, gyroscopes, telemetering, etc. Excellent openings for experienced physicists, chemists, aerodynamicists, electrical and chemical engineers. Please include detailed experience and education in reply, enclosing college transcript.

Write Aerophysics Dept. 95

NORTH AMERICAN AVIATION, INC.

Municipal Airport Los Angeles 45 California

HIGHLIGHTS........

Future Meetings. Great interest is centering around plans for the conference on electron tubes for instrumentation and other industrial uses, the first AIEE meeting of this type to be held. A substantially complete program for the conference, which is scheduled for March 29–30 at Philadelphia, appears in this issue (*pages 267–8*). A number of conferences of a similar nature are being planned for the coming year as reported in the "Future Meetings" box (*page 270*). The first of the AIEE meetings scheduled for April, the Great Lakes District meeting, will be held in Des Moines, Iowa, April 1–3. Thirteen technical papers appear on the program for this meeting (*pages 268–9*).

Winter Meeting. The verified registration figure of 3,081 at the 1948 winter general meeting in Pittsburgh, far exceeded even the most optimistic estimates of probable attendance for this meeting, which was the second winter meeting since 1924 to be held outside of New York City (*pages 272–3*). The meeting's 51 technical sessions, which included the presentation of 106 formal technical program papers and 117 conference papers, are reported in part in this issue (*pages 273–97*). A report of the remaining sessions will appear in April.

Mexico. Of especial interest to AIEE members planning to attend the 1948 summer general meeting in Mexico City, will be the discussion of a "Mexican Holiday" in which the author reveals something of the Mexican people and their country as seen at first hand by an American tourist. He strongly endorses the summer meeting theme, to make the meeting "an exciting vacation in colorful Mexico" (*pages 215–17*). In conjunction with technical program plans for the summer meeting, some of the points of technical interest in and near Mexico City which may be inspected by AIEE visitors are described (*page 270*). The "request-for-information" coupon which, upon completion and return to the AIEE, will bring travel, hotel, or other information to the sender, appears again in this issue for the convenience of the reader (*page 58A*).

Air-Borne Radar. Minor, but significant, modifications of existing *X*-band air-borne radar types have made it practical for the pilot to use radar for avoiding collisions with terrain, for emergency negotiation of "let-downs" over terrain surrounded by hills, for avoidance of dangerous areas of precipitation, and as a navigation aid. The continuous information on ground speed provided by air-borne radar provides substantial economies in long hauls by permitting quick selection of the most favorable flight levels (*pages 246–8*).

Edison Metal Presentation. The mathematician, the scientist, the engineer—these terms are defined and related by a man who has answered to all three, the 1947 Edison Medalist, Joseph Slepian, in his address at the Edison Medal presentation. Doctor Slepian was awarded the medal "for his practical and theoretical contributions to power systems through circuit analysis, arc control, and current interruption" (*pages 258–64*).

Nuclear Engineering. The discovery of uranium fission has opened another branch of engineering—nuclear engineering. Opportunity for development in this field is omnipresent, because standard practices still are being selected. This is the fourth of a series of articles developed by the AIEE nucleonics committee to serve as an up-to-date textbook of nuclear energy for the average engineer (*pages 229–32*).

Temperature Limits. "With extensive review of tests made during the past 25 years plus the results of certain self-conducted tests as its basis, the AIEE Standards committee subcommittee on conduction in stationary contact surfaces recommends various changes in the present Standards for permissible temperatures on electric contacts." Comments and criticism are invited (*pages 253–7*).

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Largest Series Capacitor Installation. To improve voltage on a 66-kv line supplying a large electric furnace, a 10,000-kva 500-ampere series capacitor has been installed. Three groups of standard 2,400-volt 15-kva units connected in series were used per phase, each group being protected by its own by-pass gap and automatic switch (*pages 236–41*).

Distribution System Modernization. Many utilities, like Topsy, have "just growed" as increased loads required increased capacity. Distribution systems in particular have fallen victim to the lack of time, capital, and manpower necessary to engineer the co-ordination and revision of practices which could effect better and more economical service. Certain consumer practices have necessitated complications of distribution. If these could be eliminated, the consumer would gain in the long run (*pages 223–8*).

New Telegraph Signal Analyzer. Immediate interpretation of the data recorded by a new portable signal analyzer enables more rapid repairs and more accurate routine checking of start-stop telegraph circuits. The distortion patterns produced by different types of interference and faults can be analyzed rapidly for degree as well as type of trouble (*pages 218–21*).

Aircraft Uses of Electricity. The story of the development of airplane auxiliary power systems is the history of successive increases in size and power of the airplanes themselves. Nothing will replace the low-voltage d-c system for small aircraft, but medium-sized and large aircraft probably will use 120-volt d-c or 400-cycle a-c systems (*pages 232–5*).

A Proportional-Frequency Telemetering System. The use of a varying-frequency 6–27-cycle sine wave for telemetering with carrier currents has introduced the possibility of obtaining continuous measurement and fast response without sacrificing high accuracy and stability of calibration. Although developed for use with current, voltage, and powers, the system has many other applications (*pages 249–52*).

Corrections. In the footnote on page 1 of "The Relation Between Energy and Mass" by Frederick Seitz, Jr., (*EE, Jan '48, pp 1–5*), energy released in the production of water was given erroneously as 2.4×10^{10}. As stated in the text, the value should be 2.4×10^{12}. The calculated values therefore should be: mass 2.7×10^{11} and mass per gram of steam 1.5×10^{-10}. Also in the January issue, on page 31 of "1947 Engineering Developments" (*pp22–31*), the Westinghouse radio-frequency generator shown in the lower left-hand corner of the page was credited erroneously to General Electric.

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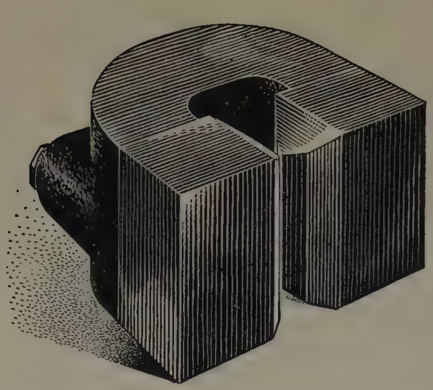


Permanent Magnets Do It Better in…

Electrocardiographs

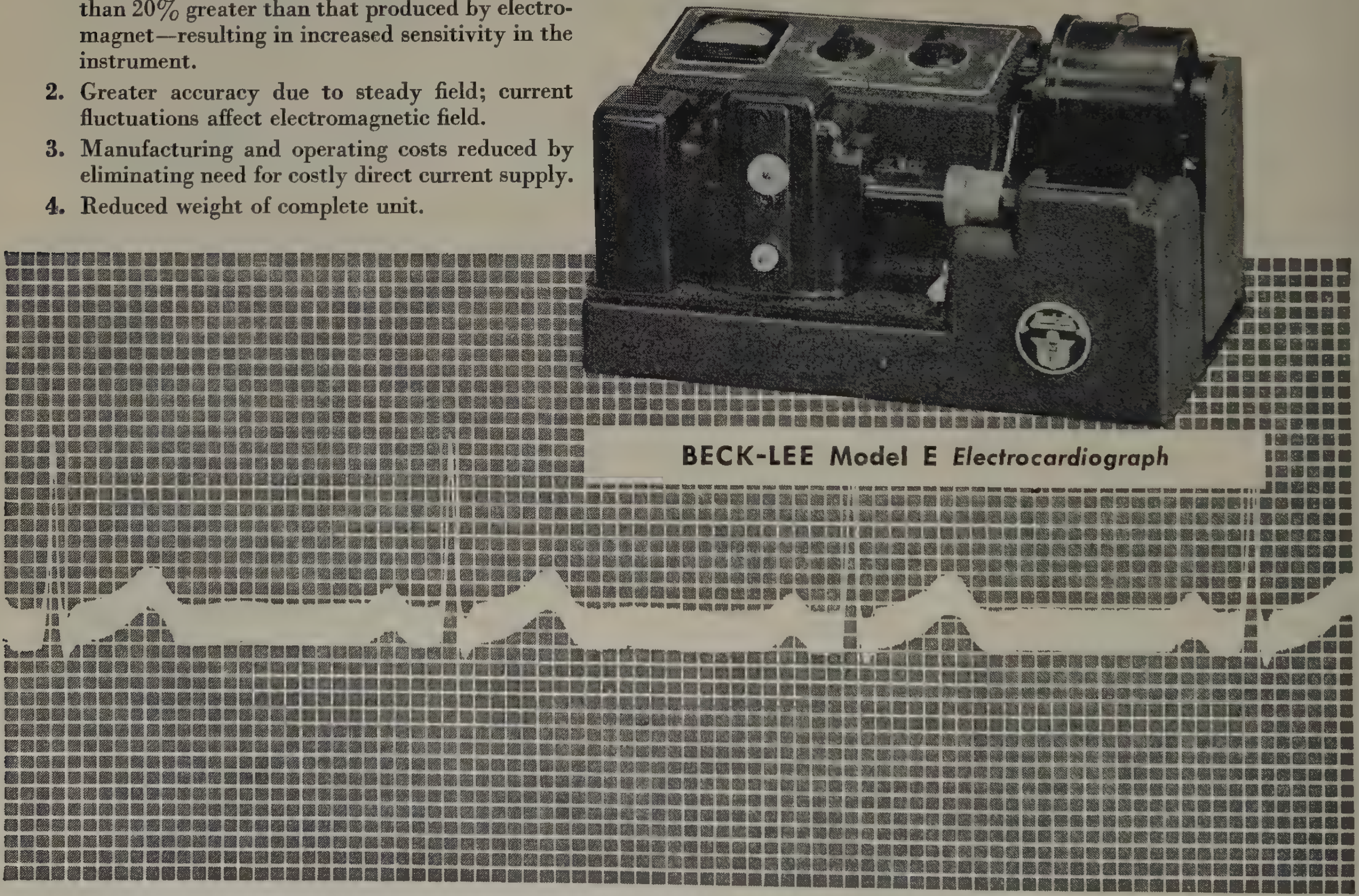
To build a better instrument for vital diagnosis, Beck-Lee Corporation, makers of precision-built Electrocardiographs, requested our engineers to cooperate in the design of a permanent magnet to replace an electromagnet to accomplish these objectives:

1. To increase the efficiency of the instrument by increased field strength.
2. Increase accuracy by eliminating field variations of electromagnet.
3. Reduce weight of complete unit.
4. Reduce cost of unit.

The resultant design—the permanent magnet illustrated—produced these results:

1. More than 20,000 gausses produced in air gap by our Alnico V magnet—a field strength more than 20% greater than that produced by electromagnet—resulting in increased sensitivity in the instrument.
2. Greater accuracy due to steady field; current fluctuations affect electromagnetic field.
3. Manufacturing and operating costs reduced by eliminating need for costly direct current supply.
4. Reduced weight of complete unit.

The Indiana Steel Products Company offers you an exceptional permanent magnet design service. A consultation with our engineers may develop unexpected savings and increased efficiency in your product through the use of permanent magnets.



BECK-LEE Model E ***Electrocardiograph***

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SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

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"...Practical Perfection..."

A. G. de Wolfe "brought to practical perfection a machine for insulating all kinds of telegraph wires," said his obituary in 1896. And at the time of his invention, the telegraph industry was the only industry requiring insulated wire.

It was Mr. de Wolfe's mechanical genius that made possible the application of A. G. Day's remarkable invention of Kerite insulation, for at the time Mr. Day produced Kerite, no suitable means of applying it to wire existed.

Down through the years, Kerite engineers have kept on working for new and better things. And they have contributed many advances to the art of cable making. But one thing has never changed:

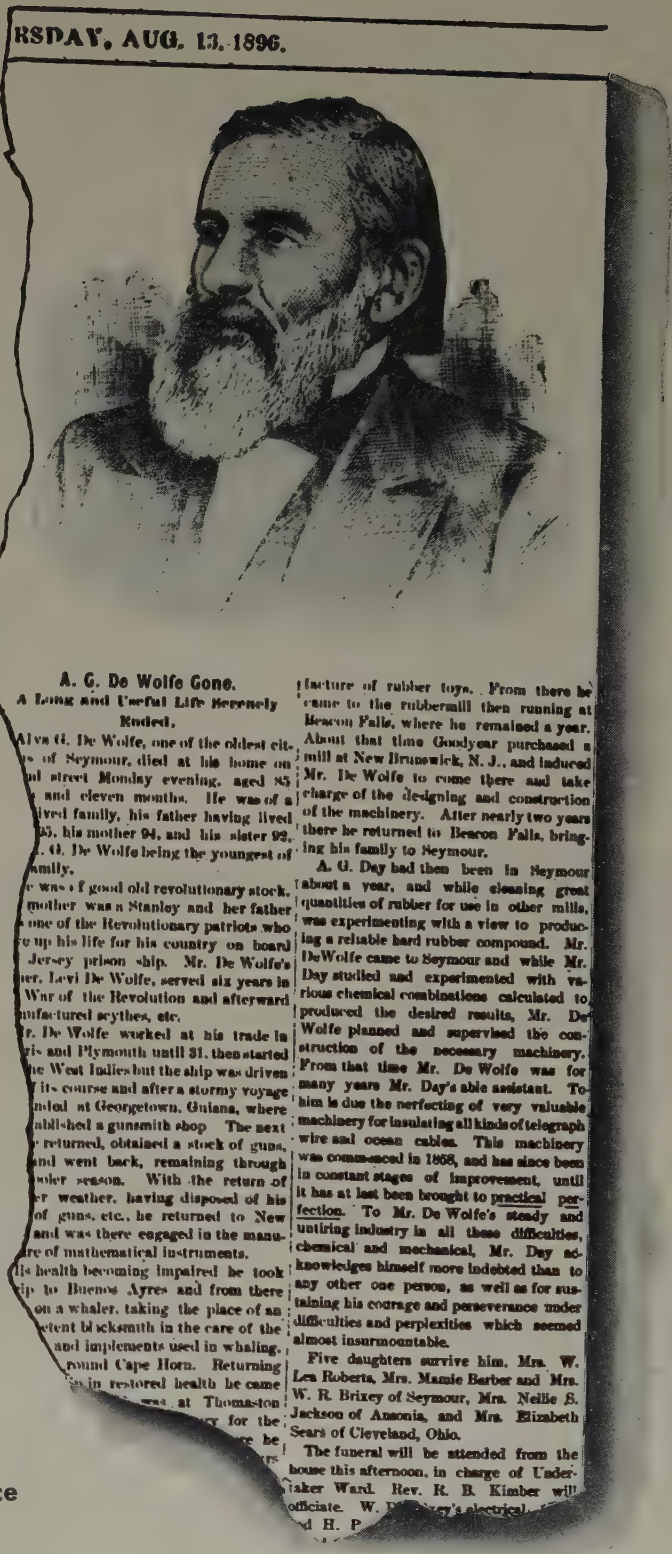
The Kerite insulation of today is still based on the original Kerite, which has always been the secret of Kerite's long life and low cost per year.

The proof of this remarkable insulation is found in Kerite cable that has been in use for nearly two generations of continuous operation.

For example, one Kerite 600-volt, 19-conductor cable installed 59 years ago still has an average breakdown voltage to ground of 31,500 volts.

Kerite insulated wire and cable is available in many forms and for many purposes—low or high voltage, indoor, outdoor, aerial or submarine. Ask any Kerite user about its stamina and low cost per year. *The Kerite Company, 30 Church St., New York 7, N. Y.*

Offices also at: 122 S. Michigan Avenue, Chicago 3; 582 Market Street, San Francisco 4; 714 W. Olympic Blvd., Los Angeles 15.



RSDAY, AUG. 13, 1896.

A. G. De Wolfe Gone.

A Long and Useful Life Serenely Ended.

Alva G. De Wolfe, one of the oldest cit- s of Seymour, died at his home on nd street Monday evening, aged 85 and eleven months. He was of a ived family, his father having lived 95, his mother 94, and his sister 92, . G. De Wolfe being the youngest of amily.

e was of good old revolutionary stock. mother was a Stanley and her father one of the Revolutionary patriots who e up his life for his country on board Jersey prison ship. Mr. De Wolfe's her, Levi De Wolfe, served six years in War of the Revolution and afterward ufactured scythes, etc.

r. De Wolfe worked at his trade in is and Plymouth until 31, then started he West Indies but the ship was driven its course and after a stormy voyage nded at Georgetown, Guiana, where ablished a gunsmith shop The next returned, obtained a stock of guns, and went back, remaining through oler season. With the return of er weather, having disposed of his of guns, etc., he returned to New and was there engaged in the manu- re of mathematical instruments.

is health becoming impaired he took ip to Buenos Ayres and from there on a whaler, taking the place of an etent blacksmith in the care of the and implements used in whaling. round Cape Horn. Returning in restored health he came was at Thomaston ry for the e he rs facture of rubber toys. From there he came to the rubbermill then running at Beacon Falls, where he remained a year. About that time Goodyear purchased a mill at New Brunswick, N. J., and induced Mr. De Wolfe to come there and take charge of the designing and construction of the machinery. After nearly two years there he returned to Beacon Falls, bringing his family to Seymour.

A. G. Day had then been in Seymour about a year, and while cleaning great quantities of rubber for use in other mills, was experimenting with a view to producing a reliable hard rubber compound. Mr. DeWolfe came to Seymour and while Mr. Day studied and experimented with various chemical combinations calculated to produced the desired results, Mr. De Wolfe planned and supervised the construction of the necessary machinery. From that time Mr. De Wolfe was for many years Mr. Day's able assistant. To him is due the nerfecting of very valuable machinery for insulating all kinds of telegraph wire and ocean cables. This machinery was commenced in 1868, and has since been in constant stages of improvement, until it has at last been brought to practical perfection. To Mr. De Wolfe's steady and untiring industry in all these difficulties, chemical and mechanical, Mr. Day acknowledges himself more indebted than to any other one person, as well as for sustaining his courage and perseverance under difficulties and perplexities which seemed almost insurmountable.

Five daughters survive him, Mrs. W. Lea Roberts, Mrs. Mamie Barber and Mrs. W. R. Brixey of Seymour, Mrs. Nellie S. Jackson of Ansonia, and Mrs. Elizabeth Sears of Cleveland, Ohio.

The funeral will be attended from the house this afternoon, in charge of Undertaker Ward. Rev. R. B. Kimber will officiate. W. [illegible]xey's electrical d H. P

Kerite Insulation—
Your Cable's Best Life Insurance

KERITE CABLE

INDUSTRIAL NOTES....

Elevator Furnace. Among equipment recently installed to increase production of large transformers and feeder regulators at the main works of Allis-Chalmers Manufacturing Company, Milwaukee, Wis., is an electrically heated 180-kw 208-volt 3-phase high-temperature elevator furnace for tempering punchings of magnetic materials in a hydrogen or nitrogen atmosphere up to a maximum temperature of 2,150 degrees Fahrenheit.

Battelle Appointment. Doctor Edward H. Gamble has joined the staff of Battelle Institute, Columbus, Ohio, where he will engage in research in industrial physics.

Purchase Completed. The Jefferson Electric Company, Bellwood, Ill., has purchased the Capacitron Company, Inc., of Chicago. Plans have been made to continue the production of condensers and capacitors in the present Capacitron Company plant, enlarging and improving facilities as required.

New Company. A new company, Surveys, Inc., with main offices in Palo Alto, Calif., will make available to educational and industrial organizations placement techniques, training services, job evaluation methods, and special economic surveys.

Export Department Established. Duro-Test Corporation, North Bergen, N. J., announces the establishment of an export department. J. A. de Martino, formerly of RCA-International, will head the new department as export manager.

Acquisition. Johns-Manville Corporation, New York, N. Y., has announced the purchase of Van Cleef Bros., Inc., of Chicago, Ill., well-known manufacturers of "Dutch Brand" industrial and automotive products.

New Bearing Firm. Dalc Bearings, Inc., has been organized to specialize in the engineered application and sale of antifriction bearings.

Move. The Fluorescent Lighting Association has moved to 501 Fifth Avenue, New York, N. Y.

New Birmingham Warehouse. Oliver Iron and Steel Corporation, Pittsburgh, Pa., announces the purchase and opening of a new warehouse in Birmingham, Ala., as a step in its southern expansion program. The new warehouse is located at 2431 North 29th Avenue.

New Firm. A new company, International Rectifier Corporation, announces the opening of a plant at 6809 Victoria Avenue, Los Angeles, Calif. The new firm is equipped for research and manufacture in the field of colorimetric equipment, photoelectric cells, and selenium rectifiers.

Merger. Robertshaw Thermostat Company, Youngwood, Pa.; The Fulton Sylphon Company, Knoxville, Tenn.; and the Bridgeport Thermostat Company, Inc., Bridgeport, Conn.; have merged under the name of Robertshaw-Fulton Controls Company.

Cope Moves. T. J. Cope, Inc., has purchased a plant at 711 South 50th Street, Philadelphia 43, Pa.

Plant Manager. J. L. Miller, production superintendent at the Zelienople, Pa., Johns-Manville factory since 1942, has been appointed plant manager.

Chief Engineer. M. W. Reid has been appointed chief engineer, United States Steel Corporation of Delaware.

Argentinian Order. International General Electric Company, Inc., has announced that a contract has been signed in Buenos Aires between General Electric South America, Argentina, and the Argentine State Railways, under which General Electric will supply Argentina with 95 Diesel-electric locomotives within the next three years.

(*Continued on page 36A*)

2-inch wattmeter....

(Electrodynamometer Type)

Another Simpson First....

...for discriminating users of fine panel instruments

(ACTUAL SIZE)
Also available in various sizes and case styles. For complete information write for bulletin.

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ELECTRIC COMPANY, 5200-5218 West Kinzie Street, Chicago 44, Illinois
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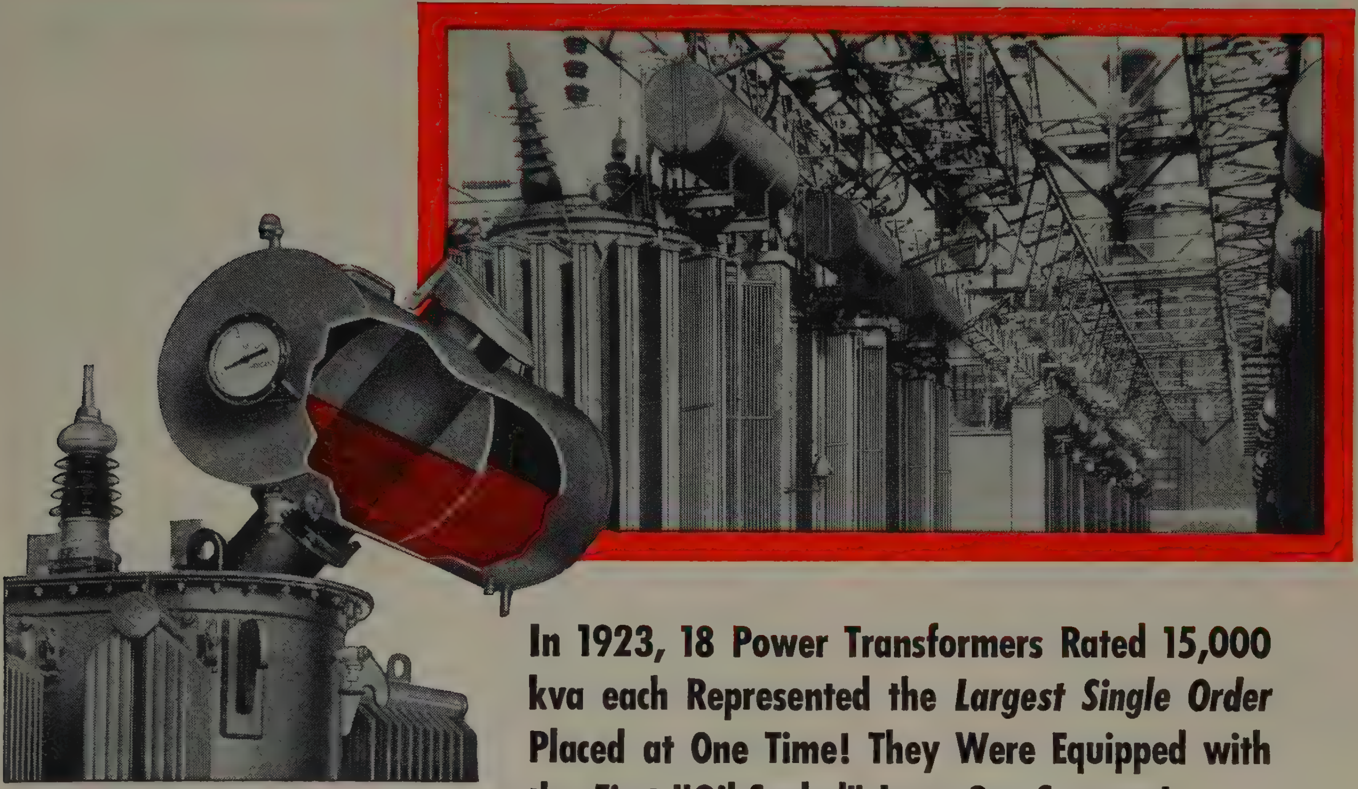
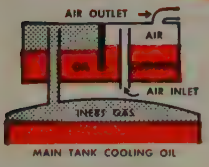
NOT ONE, BUT

Two Big "Firsts"

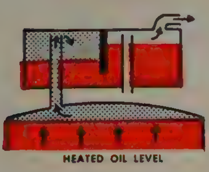


In 1923, 18 Power Transformers Rated 15,000 kva each Represented the *Largest Single Order* Placed at One Time! They Were Equipped with the *First* "Oil-Sealed" Inert Gas Systems!

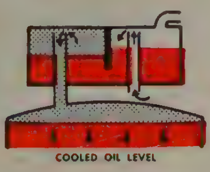
SIMPLE AS A·B·C



A PRINCIPLE — Transformer cooling oil is isolated from the atmosphere by inert gas and oil seal. This prevents sludge formation and fire hazard due to oxygen. Excluding moisture maintains high dielectric quality of oil.



B AS TRANSFORMER HEATS, the cooling oil expands, displacing inert gas from main tank to auxiliary tank. The transfer of gas is cushioned by the change of oil levels as shown, keeping the main tank pressure low.



C AS TRANSFORMER COOLS, the reverse takes place. In this simple manner inert-gas protection is provided automatically . . . transformer oil adjusts itself to changing temperatures without being exposed to the atmosphere.

AFTER 24 YEARS OF SERVICE these *original* "Oil-Sealed" inert gas systems are still in operation! From the original 270,000 kva installation the Oil-Sealed system has grown in acceptance until it is standard for over 5,000,000 kva of U. S. power!

What's behind this leadership; how does it benefit you? Allis-Chalmers *pioneering* and continued efforts behind inert-gas protection have gone a long way toward the *standardization* of protection which the industry accepts today. In addition, the "Oil-Sealed" system has gained steadily increasing acceptance . . . because of its unfailing simplicity.

This remarkable system has no moving parts; no sensitive gauges or reduction valves. It does not require periodic replenishment of nitrogen; no bottles to buy. It is the lowest-pressure system available — generally not exceeding 1 lb per sq in.; and that means low pressure on gaskets, lower maintenance. System can be mounted top-of-tank or on side. ALLIS-CHALMERS, MILWAUKEE 1, WIS.

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"Oil-Sealed" Is an Allis-Chalmers Trademark

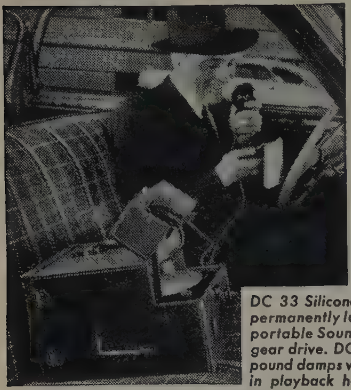
ALLIS-CHALMERS MILWAUKEE A-C

ALLIS-CHALMERS

Originators of the "Oil-Sealed" Inert Gas System!

Silicone News
DC SILICONES

DC Silicones Help Maintain High Performance Standards of Portable SoundScriber



DC 33 Silicone Grease permanently lubricates portable SoundScriber gear drive. DC 4 Compound damps vibrations in playback head.

A portable recording machine that can be used in your car is obviously subject to operation in extremes of temperature. Yet turntable speeds are critical. The SoundScriber Corporation, New Haven, Connecticut, has solved this problem with a sealed gear drive mechanism permanently lubricated with DC 33 Silicone Grease.

Here are the benefits reported from the use of DC 33 Silicone Grease in the drive mechanism:

1. It eliminates the need for relubrication; DC 33 does not evaporate or dry out.
2. DC 33 retains its consistency and provides effective lubrication at temperatures ranging from —95° to 300° F. It therefore permits the motor to start easily and operate satisfactorily when cold; it does not thin out and leak through bearing joints at high temperatures as do other greases or oils having a low enough torque at low temperatures.

And here are the advantages of DC 4 Silicone Compound as used in the playback heads of all models of the SoundScriber:

1. It effectively damps the moving coil of this playback uniformly at any temperature—giving an "oil damping" effect without requiring elaborate sealing devices.
2. DC 4 is inert to most organic materials. It can, therefore, be used in direct contact with the rubber supports in the playback heads.

Dow Corning Silicone Products are notably indifferent to temperature changes. They possess other unique properties that may be even more useful to you. We've had nearly five years' experience in the commercial production of Silicone Greases, Fluids, Resins, and Silastic*. Telephone the branch office nearest you for engineering assistance, or write for Catalog A1-4.

*TRADEMARK FOR DOW CORNING SILICONE RUBBER

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
New York • Chicago • Cleveland • Los Angeles
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

(*Continued from page 14A*)

Promotions. Frederick J. Sager has been named treasurer of RCA Communications Inc., New York, N. Y., and Ashton Dunn, Jr., has been named director of personnel of RCA Communications.

Westinghouse Appointments. Herman J. Mauderer has been named vice-president and auditor, Arthur L. Partridge has been appointed assistant to the president, and J. D. Mickle has been appointed manager of the import department, of Westinghouse Electric International Company.

Consolidation. Bendix Aviation Corporation Eclipse Pioneer Division has announced the consolidation of sales and service facilities on the West Coast. Activities of the consolidation will be directed from offices of the Bendix West Coast division's new building, at 17 East Providencia Avenue, Burbank, Calif.

Attorney Joins RCA. Samuel E. Ewing, Jr., has joined the legal department of the RCA Victor Division, Radio Corporation of America, Camden, N. J.

GE Assistant Manager. Frank T. Lewis has been appointed assistant manager of General Electric's Schenectady works.

Westinghouse Output. To help meet an all-time record demand for electric power, the Westinghouse Electric Corporation is turning out steam turbine generating equipment at a rate nearly double that of any previous year. The company expects to continue this rate of production of electric power generating equipment through 1950. Production of associated electric equipment is also at a new high. Output of distribution transformers is running at a rate twice that of 1941 and meter production at a rate better than 50 per cent above that year. Dollar volume of switchgear for controlling and regulating electric power is running 100 per cent ahead of 1941.

Wade Atkinson has joined the public information department, Frigidaire division, General Motors Corporation, Dayton, Ohio.

Representatives Announced. Burlington Instrument Company, Burlington, Iowa, announces the appointment of the following as representatives to handle Burlington electric indicating instruments: Corcoran-Hall Company, 842 Hamilton Street, Allentown, Pa.; W. Clif McLoud and Company, 711 Colorado Building, Denver 2, Colo.; David Ross and Company, 108 Ninth Street, San Francisco 3, Calif. Corcoran-Hall will handle the entire state of Virginia with the exception of Fairfax County. W. Clif McLoud and Company will handle the states of Wyoming, Utah, and Colorado. David Ross and Company will take care of the state of California, north of and including the counties of Monterey, Kings, Tulare, and Inyo.

Sperry to Relocate. Sperry Products, Inc., will move its manufacturing plant

(*Continued on page 46A*)

New Books

Electric Power Transmission
by M. P. Weinbach

A very thorough treatment of the theory involved, including full explanations of the mathematical methods used in the solution of transmission problems. The complex problems of the long line are discussed in detail. Special attention is given to factors affecting the economy and efficiency of service, such as maintenance of constant voltage at system termini through control of reactive power, stability characteristics, steady-state power limits, and the causes and severity of faults. $5.50

Fundamental Electronics and Vacuum Tubes
by Arthur L. Albert

This is a new revised edition of a book widely used as an electrical engineering text and reference. It presents complete, up-to-date explanations of electronic theory and shows the applications both to communication and to power engineering. The latest standards of the AIEE and IRE are followed throughout the book. You will find here up-to-date, full and accurate answers to all fundamental questions about the various electronic tubes and tube circuits, their analysis and use. $6.00

SEE COPIES ON APPROVAL

The Macmillan Co., 60 Fifth Ave., New York 11

Please send me on 10 day's approval
☐ Electric Power Transmission $5.50
☐ Fundamental Electronics & Vacuum Tubes $6.00

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Address ______

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(*Please give postal zone no.*) E

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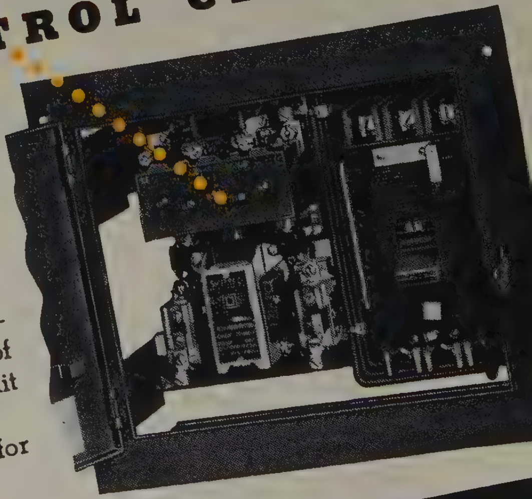
Here is a good reason for specifying Square D CONTROL CENTERS



• Control centers permit low-cost grouping of starters in favorable locations. They offer the basic advantages of attractive appearance, compactness, easy installation, convenient maintenance and adaptability to future change or expansion.

You get better performance in Square D Control centers because each of the basic advantages is greatly increased by the time-proved design and operation of Square D Starters plus the inherent value of Circuit Breaker protection.

Call your nearby Square D Field Engineer for complete details.

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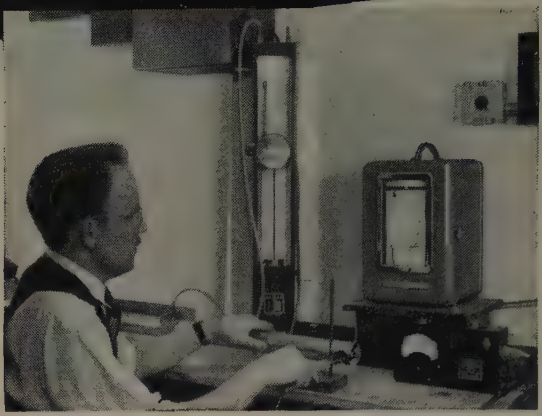
HIGH-SPEED RECORDING PROBLEMS SOLVED...

by Photoelectric Recorder..



Further proof that the G-E Photoelectric Recorder can record anything that can be measured is found in the Illinois Testing Laboratory, Inc. Their engineers say, "The G-E Photoelectric Recorder provides a versatile, sensitive recording unit for temperature, light, and electrical phenomena." As shown above they are using it to record very low air velocities measured by their thermo-anemometer, an instrument for air circulation tests.

The extreme sensitivity and high-speed response of the photoelectric recorder make it ideally suited to this application, as well as for thermocouple response tests and resistance thermometry. It gives a complete recorded history of these operations.

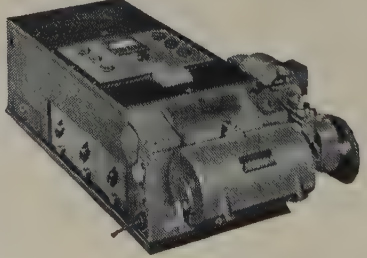
The Illinois Testing Laboratory, Inc. is just one of the many users who have found the G-E Photoelectric Recorder useful in solving their recording problems. There are many other applications embracing the entire field of measurements, since the recorder can *record* anything that can be *measured*.

A wide range of sensitivities (which go as low as 1.0 microamperes for full scale deflection) and response speeds as high as 1/4 second are available in the photoelectric recorder. Basic elements are interchangeable so that one instrument can cover a number of ranges. It is also available as a potentiometer recorder. Write for Bulletin GEA-2394, or contact your nearest G-E sales office and let us help you with your application problems.

PM-10 OSCILLOGRAPH

Increase the scope of your investigations, design, and testing of many types of machines and devices. The General Electric PM-10 Oscillograph provides a permanent record of—

Voltage
Current
Time
Speed
Pressure
Stress
Strain
Sound
Vibrations



This oscillograph includes simultaneous viewing with recording, which permits traces to be shown continuously on the viewing screen. Wave shapes or deflection can be observed, as well as the arrangement of waves.

Benefit from the extreme sensitivity and versatility of this instrument. Write for Bulletin GEA-3662 today. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

GENERAL ELECTRIC

602-118

(*Continued from page 36A*)

and general offices from Hoboken, N. J., to Danbury, Conn., during the summer of 1948. A 20-acre site has been acquired and construction of a monitor-type manufacturing building and a three story office building will begin immediately.

Named to Executive Post. W. G. Miller has been appointed assistant to the works manager of the Buffalo divisions of the Westinghouse Electric Corporation, Buffalo, N. Y.

TRADE LITERATURE

Biddle Instrument News. The September issue of this publication covers such subjects as ground testing and the new Biddle multirange frequency meter and transformer turn ratio test set, as well as other information on related subjects. Copies of *Biddle Instrument News* are available without charge by writing to the James G. Biddle Company, Department B-7, 1316 Arch Street, Philadelphia 7, Pa.

Water Demineralizers. Booklet, 26 pp. The advantages of demineralized water over distilled water are noted. The booklet describes briefly the chemical and mechanical principles of demineralization by ion exchange, and gives data on calculating costs for demineralizing various raw waters. "Filt-R-Stil Demineralizers, Chemical Equivalent of Distilled Water." American Cyanamid Company, Ion Exchange Products Department, 30 Rockefeller Plaza, New York 20, N. Y.

Crystal Data. Bulletin *201*, 4 pp. Technical data covering 12 widely used crystal types are given. Illustrated with photographs and drawings, the bulletin provides specifications of crystal characteristics, frequency ranges, construction features, and physical dimensions. Premier Crystal Laboratories, Inc., 57–67 Park Row, New York 7, N. Y.

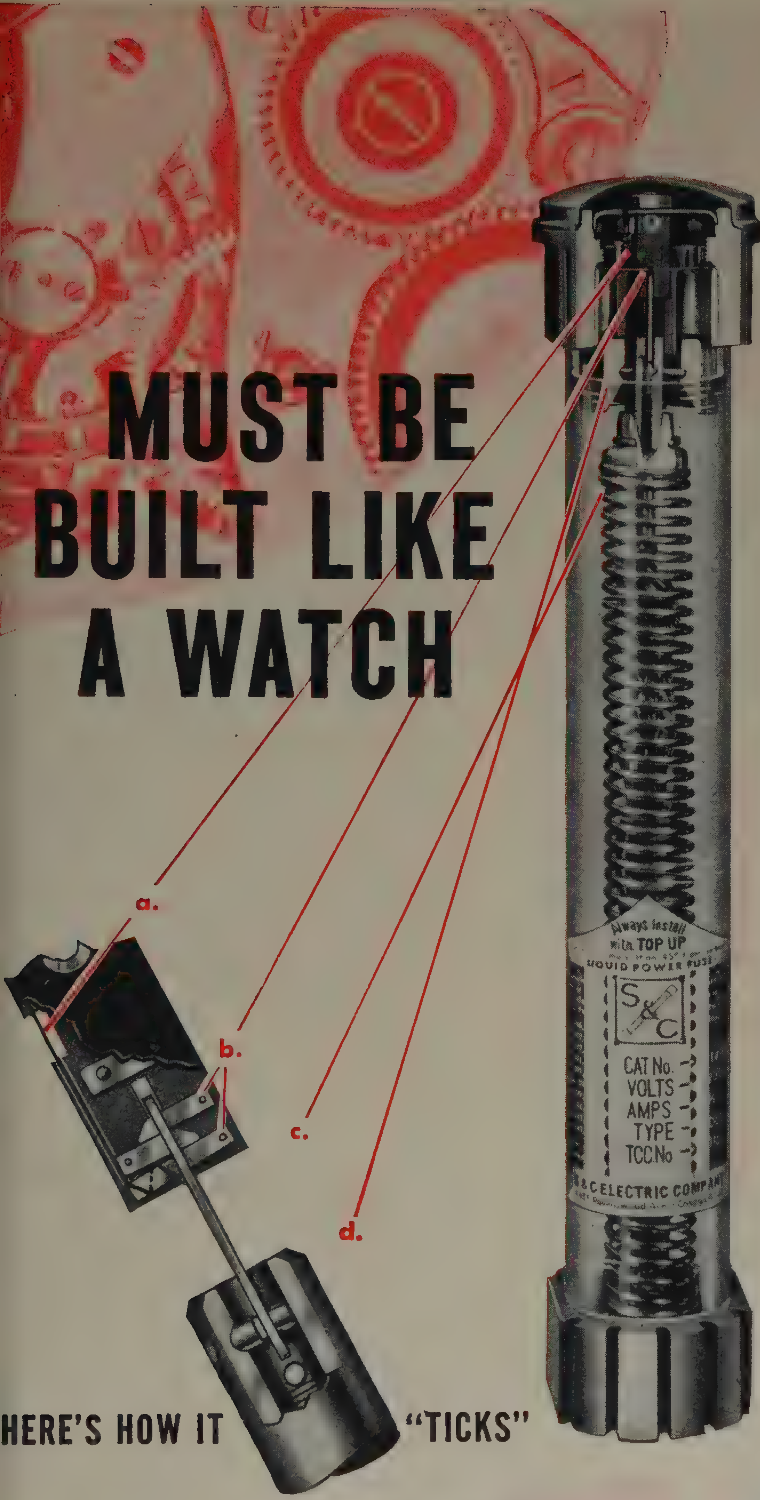
Torque Indicators. Bulletin, 4 pp. Six models with capacities ranging from 50 to 1,000 foot-pounds are described in catalogue bulletin *46T*. Blackhawk Manufacturing Company, Milwaukee 1, Wis.

Resonant Relays. Catalogue *116A*. Information about Stevens-Arnold resonant relays used for remote control purposes which previously have been made only in the range of 153 to 442 cycles per second is given in this catalog. This range had been extended to 1,000 cycles per second. Stevens-Arnold Inc., 22 Elkins Street, South Boston 27, Mass.

Materials Handling. Book. Co-ordination of all steps in materials handling at relatively low cost is described. Among subjects covered in the book are concentration of materials within easy reach of

(*Continued on page 52A*)

MUST BE BUILT LIKE A WATCH



HERE'S HOW IT "TICKS"

a. Fusible Element—as low as ½ ampere rating—shielded against corona, and non-damageable by vibration or abrasion.

b. Series of Levers—150 to 1 ratio—reduces tension on fusible element of heavy coil spring.

c. Coil Spring—contracts when fusible element melts—instantly separates arcing terminals and, through the liquid director attached thereto, forces liquid into the arc space.

d. Arc-Extinguishing Liquid—close to fusible element and ready for instant action—quenches arc in approximately ½ to 1½ cycles.

For Adequate Protection in Potential Transformer Installations

Because a potential transformer fuse should provide protection in case of secondary short circuit, as well as on primary faults, it presents a problem in fuse design, of resolving two opposing extremes. On the one hand is the requirement of very low ampere rating which calls for a small, hair-fine fusible element. On the other hand, the necessity for low fault current interrupting ability requires this small element to give reliable support under tension to the heavy coil spring that provides terminal separation during fuse operation.

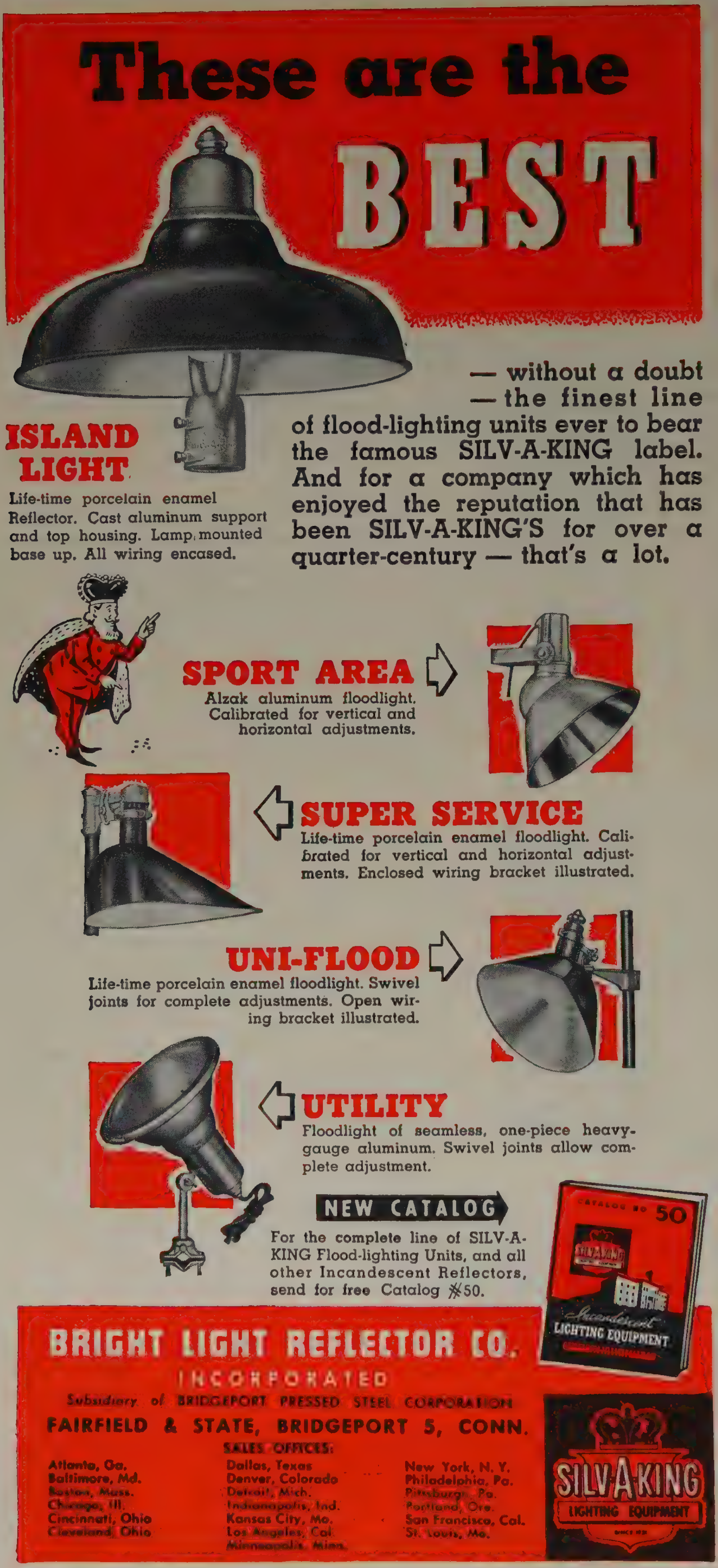
In the S & C Type D (Low Current) Liquid Fuse for potential transformers, the problem has been neatly solved with a series of tension-reducing levers of watch-like delicacy which links the powerful coil spring to the tiny fusible element without placing any undue strain on the latter.

The complete dependability of this fuse in low fault interruption also results from the correct use of liquid as the arc-extinguishing medium. On melting of the fusible element, this liquid is instantly forced by positive, mechanical action into and around the arc—immediately quenching it.

To provide adequate protection in primary short circuits . . . which in some cases might involve more than a million kva, and are frequently most severe in indoor potential transformer installations at central stations . . . a fuse must permit combination with a current limiting resistor, and must operate without expulsion effect. Here, also, this Liquid Fuse meets the requirements.

Ask, today, for full information on this superior fuse for potential transformer application.

S&C ELECTRIC COMPANY
4427 Ravenswood Avenue
Chicago 40, Illinois, U. S. A.
Formerly SCHWEITZER & CONRAD, INC.



These are the BEST

— without a doubt — the finest line of flood-lighting units ever to bear the famous SILV-A-KING label. And for a company which has enjoyed the reputation that has been SILV-A-KING'S for over a quarter-century — that's a lot.

ISLAND LIGHT
Life-time porcelain enamel Reflector. Cast aluminum support and top housing. Lamp mounted base up. All wiring encased.

SPORT AREA
Alzak aluminum floodlight. Calibrated for vertical and horizontal adjustments.

SUPER SERVICE
Life-time porcelain enamel floodlight. Calibrated for vertical and horizontal adjustments. Enclosed wiring bracket illustrated.

UNI-FLOOD
Life-time porcelain enamel floodlight. Swivel joints for complete adjustments. Open wiring bracket illustrated.

UTILITY
Floodlight of seamless, one-piece heavy-gauge aluminum. Swivel joints allow complete adjustment.

NEW CATALOG
For the complete line of SILV-A-KING Flood-lighting Units, and all other Incandescent Reflectors, send for free Catalog #50.

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Pittsburgh, Pa.
Portland, Ore.
San Francisco, Cal.
St. Louis, Mo.

(Continued from page 46A)

operators, vertical and horizontal expansion, practical stacking and storing, the elimination of waste motion in handling, and the use of movable transports, bin sections, die and shelf racks, pallets, shop boxes, and trays. The systematic movement of products or parts through the plant and a series of interlocking units are explained in other sections of the book which is called "The Turner System of Materials Handling." Factory Service Company, 4615 North 21st Street, Milwaukee 9, Wis.

NEW PRODUCTS • • • •

Drill Press Attachments. The J. D. Whittle Company announces four new interchangeable drill press attachments which will enable the user to sand, drive screws, polish, grind, file, in addition to sawing wood, steel, plastic, and other similar materials, all with the same power unit.

GE 10-Kw Frequency Modulation Transmitter. A new 10-kw frequency modulation transmitter, type *BT-4-A*, using the Phasitron modulator, has been developed by the transmitter division of the General Electric Company at Electronics Park in Syracuse, N. Y. This transmitter utilizes the standard 3-kw frequency modulation broadcast transmitter as the center part of the unit assembly.

Transformers for Converting Watt-Hour Meters to Kilovolt-Ampere Meters. A line of adjustable phase shifting transformers that will convert standard watt-hour meters to kilovolt-ampere hour meters by the displaced voltage method is announced by Westinghouse Electric Corporation, Pittsburgh, Pa. The new transformers shift the voltages by 0, 30, 45, and 60 degrees corresponding to 100, 86.6, 70.7, and 50 per cent power factor respectively, depending upon the position of movable plugs inserted in radio-type sockets built into the units.

Plastic Clamps. Plastic cable clamps are brought to the market by American Molded Products Company, 1644 North Honore Street, Chicago 22, Ill. Important improvements claimed for these clamps are dielectric characteristic, a new factor in cable clamps made possible by the use of plastic, affording protection from the liability to short circuit of worn cables or wire covering; lightness; ease of handling and installation; resistance to weather and fumes; freedom from corrosion; longer service. The new clamps are furnished in three sizes: three-eighths inch, one-half inch, and five-eighths inch.

Coaxial Cutter. A new coaxial cutter designed for one hand operation, and operating on a shear principle with a convex blade working against a straight blade, is introduced by Mathias Klein and Sons of Chicago, Ill.

HIGHLIGHTS........

Future AIEE Meetings. The AIEE North Eastern District will meet in New Haven, Conn., April 28–30. Ten technical and two Student sessions are scheduled, as well as inspection trips, entertainment, and a special program for the women (*pages 375–7*). A full-day technical conference on electrical problems, sponsored jointly by the AIEE subcommittee on rubber and plastics industries and the AIEE Akron Section, will be held in Akron, Ohio, April 30 (*page 375*).

Mexico Meeting. As preliminary plans for the summer general meeting in Mexico City progress, it is advised that persons interested in attending the meeting immediately return the request-for-information coupon (*EE, Feb '48, p 56A; EE, Mar '48, p 58A*) to receive desired information of transportation, hotels, and sightseeing (*pages 381–2*). In relation to these meeting plans, C. S. Purnell, chairman of the special meeting committee, recently spent a week in Mexico City in direct conference with the local general meeting committee there (*page 382*). On behalf of the Mexico Section, the chairman of the general meeting committee in Mexico City extends an invitation to Institute members to make the summer meeting a holiday in Mexico (*page 382*).

Winter Meeting Sessions. Because of space limitations, only a partial report of the 51 technical sessions held at the 1948 AIEE winter general meeting in Pittsburgh, Pa., January 26–30, could be accommodated in *ELECTRICAL ENGINEERING* for March (*EE, Mar '48, pp 272–96*). The report of the meeting is completed in this issue (*pages 383–404*).

Year Book Publication Date. Effective with the 1948 edition, the "AIEE Year Book" will be published and distributed in the early fall, probably September, instead of in the spring as has been customary (*page 377*).

New Technical Digests. As a further step to improve service to readers of *ELECTRICAL ENGINEERING*, hereafter comprehensive digests of the technical program papers will appear in place of the former very short abstracts which were published in meeting groups (*page 378*).

Advance Pamphlet Price Change. Advance pamphlet copies of technical program papers, formerly priced on a sliding scale based on the physical size of the individual paper, now are available at the flat price of 30 cents per copy to members, 60 cents to nonmembers, whether purchased from headquarters, or at the meeting (*page 378*). These prices became effective with the preprints for the Great Lakes District meeting as indicated with the abstracts of these papers published in the March issue (*EE, Mar '48, pp 265–6*). The price information in the customary explanatory paragraph accompanying the afore-mentioned abstracts, however, through an oversight was not corrected, and so should be disregarded.

AIEE *PROCEEDINGS*. The fourth *PROCEEDINGS* order form, for papers presented at the 1948 winter general meeting, appears on pages 49A and 50A of this issue (*page 401*). The AIEE *PROCEEDINGS* box gives the location of order forms appearing in previous issues, together with the meetings to which they pertain (*page 378*).

Nuclear Radiation Measurement. The fourth article of the series developed by the AIEE nucleonics committee is a summary of methods used for the detection and measurement of nuclear radiation. The series as a whole will be a valuable background for a basic understanding of this newest facet of engineering science (*pages 325–32*).

National Engineering Association. President Hull reiterates his belief in the necessity for the formation of an engineering organization representative of all engineers, an American Engineering Association. His proposal for a constitutional convention of all engineering societies to consider such an organization has been endorsed by the AIEE board of directors. Letters of comment on this subject are invited by the editor (*pages 313–17*).

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Power and Defense. An adequate supply of electric power is essential to the preparation and carrying out of an adequate program of national defense, as has been proved so vividly by two world wars, just as it is essential to the maintenance of a healthy peacetime economy (*pages 319–24*).

Politics and Science. Is the loss of political liberty the price we must pay for increasing industrialization? The author warns us that we must understand clearly the many ways in which technology encroaches upon political liberalism, that not machine politics but machine-made politics should be our chief concern, for "in order better to comply with the demands of the machine, we unconsciously are fashioning our own political prison" (*page 333–7*).

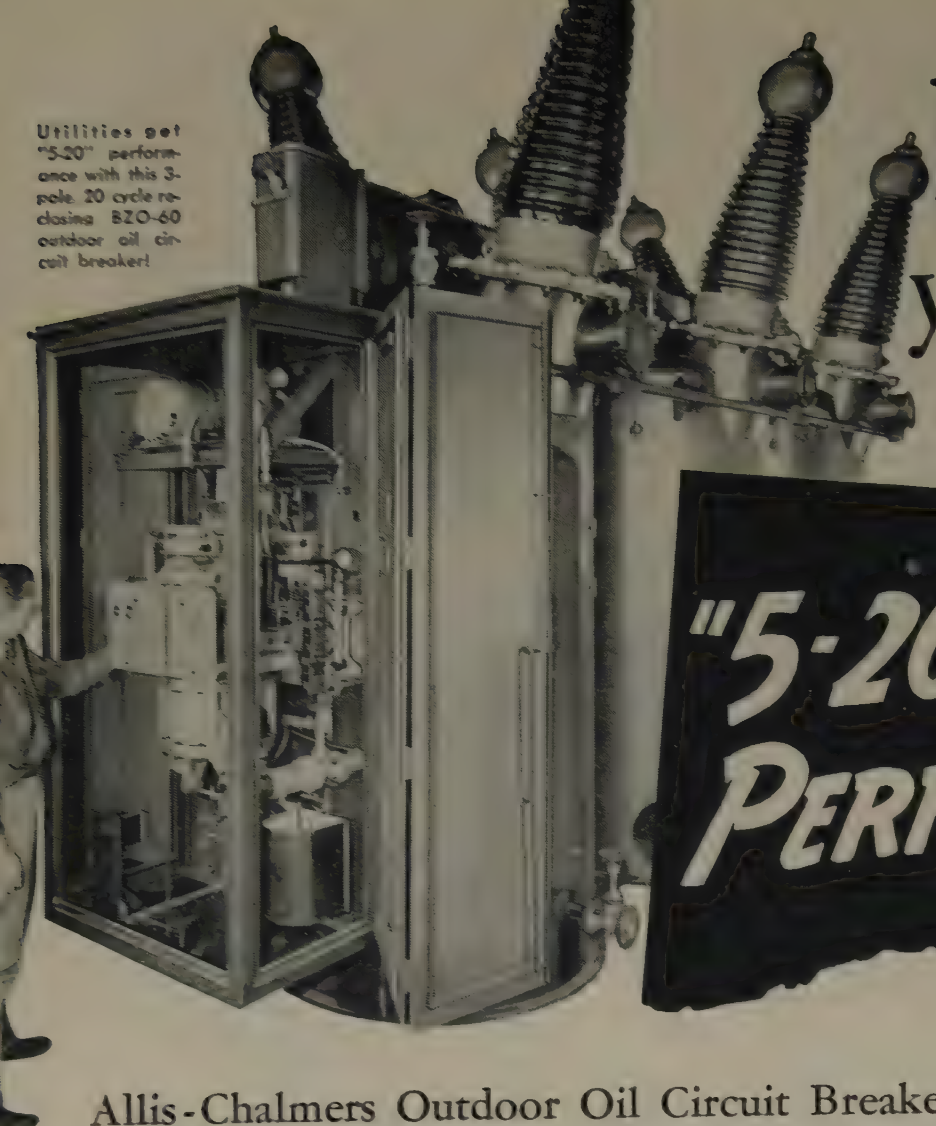
Heat Pump Opens New Horizons. Varying and divergent views of the effect of the heat pump on residential heating practice were presented at a symposium led by M. M. Brandon (F '44) Underwriters' Laboratories, New York, N. Y., at the 1948 AIEE winter general meeting (*pages 338–48*).

Industrial Voltages Reviewed. The importance of proper utilization voltage is emphasized by the report of the subcommittee on industrial voltage requirements. An analysis is made of present practices and recommendations received from industrial electrical engineers. Recommendations are made for preferred voltage spreads, voltage ratings, and taps for industrial power transformers. The subcommittee will welcome comments (*pages 358–74*).

Energy Source. Part 1 of a 2-part article considering the electrochemical sources of electric power discusses the history of the battery. This article is one of a series appearing in *ELECTRICAL ENGINEERING* for the purpose of reviewing the various known methods of producing electric power (*pages 354–7*).

Correction. Two AIEE members who attended the winter general meeting in Pittsburgh find themselves misidentified in the photograph in the lower right-hand corner of page 281 of the March issue as the result of a printer's error. C. F. Wagner (F '40) of the publications committee appears, of course, at the left of this photograph, while Lloyd F. Hunt (F '38) Southern California Edison Company, Ltd., is at the right.

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices 500 Fifth Avenue, New York 18, N. Y. Subscription $12 per year plus extra postage charge ao all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P: L. & R. Act of February 28, 1925 April 1948, Vol. 67, No.4 . Number of copies of this issue 45,000



Utilities get "5-20" performance with this 3-pole 20 cycle reclosing BZO-60 outdoor oil circuit breaker!

Protect your system with...

"5-20" BREAKER PERFORMANCE!

Allis-Chalmers Outdoor Oil Circuit Breakers Rated 115 kv and Up, Now Equipped with New 5-Cycle "Ruptor" and Pneumatic Operator!

INTERRUPTION IN 5 CYCLES ... reclosing in 20—that's "5-20" breaker performance. It means *added stability* for your high voltage lines ... safeguards *continuous service* for your *customers* ... provides *best protection* for all concerned!

For breakers themselves, "5-20" performance means *greatly minimized contact wear, less oil deterioration.* It assures minimum arc energy release and low tank pressures.

If you're planning system expansion that calls for new breakers, you will want to get the *full* story on Allis-Chalmers "5-20" breaker performance.

Proved by almost 15 years of operation on breakers rated 7.5 kv and up, you can expect such benefits as:

☛ Contact Simplicity—single-break contact design — with reliable, high-speed performance.

☛ High Arc Quench Efficiency—"Ruptor" device (single-break with 2 units per pole) snuffs out heavy short circuit arc within 0.055 of a second from parting of contacts.

☛ Quick Contact Inspection — easy removal of "Ruptor" shell unit exposes contacts. Operation may be checked by manual closing of breaker.

For complete information on 5-cycle "Ruptor" equipped (115 to 230 kv ... 1,500,000 to 3,500,000 kva) or other breakers to meet your requirements, call your nearby A-C Sales Office, or write ALLIS-CHALMERS, MILWAUKEE 1, WIS.

PRINCIPLE OF "5-20" BREAKER PERFORMANCE EXPLAINED

NEW 5 CYCLE dynamic (single break) "Ruptor" includes 2 devices per pole. "Ruptor" limits arc energy release ... helps to maintain dielectric strength of oil in tank. Electrostatic shield, left, increases insulation factor between contacts and tank.

1—Like arrows from a bow, contacts open lightning-fast upon release of stored energy in powerful accelerating springs!

2—Like a tornado, pressure created by arc swirls oil through helical throat, developing great oil turbulence in "Ruptor" ... quenching arc and clearing arc path ... interrupting circuit in 5 cycles or less from energization of trip coil.

3—Ultra-rapid pneumatic operator recloses breaker within 20 cycles.

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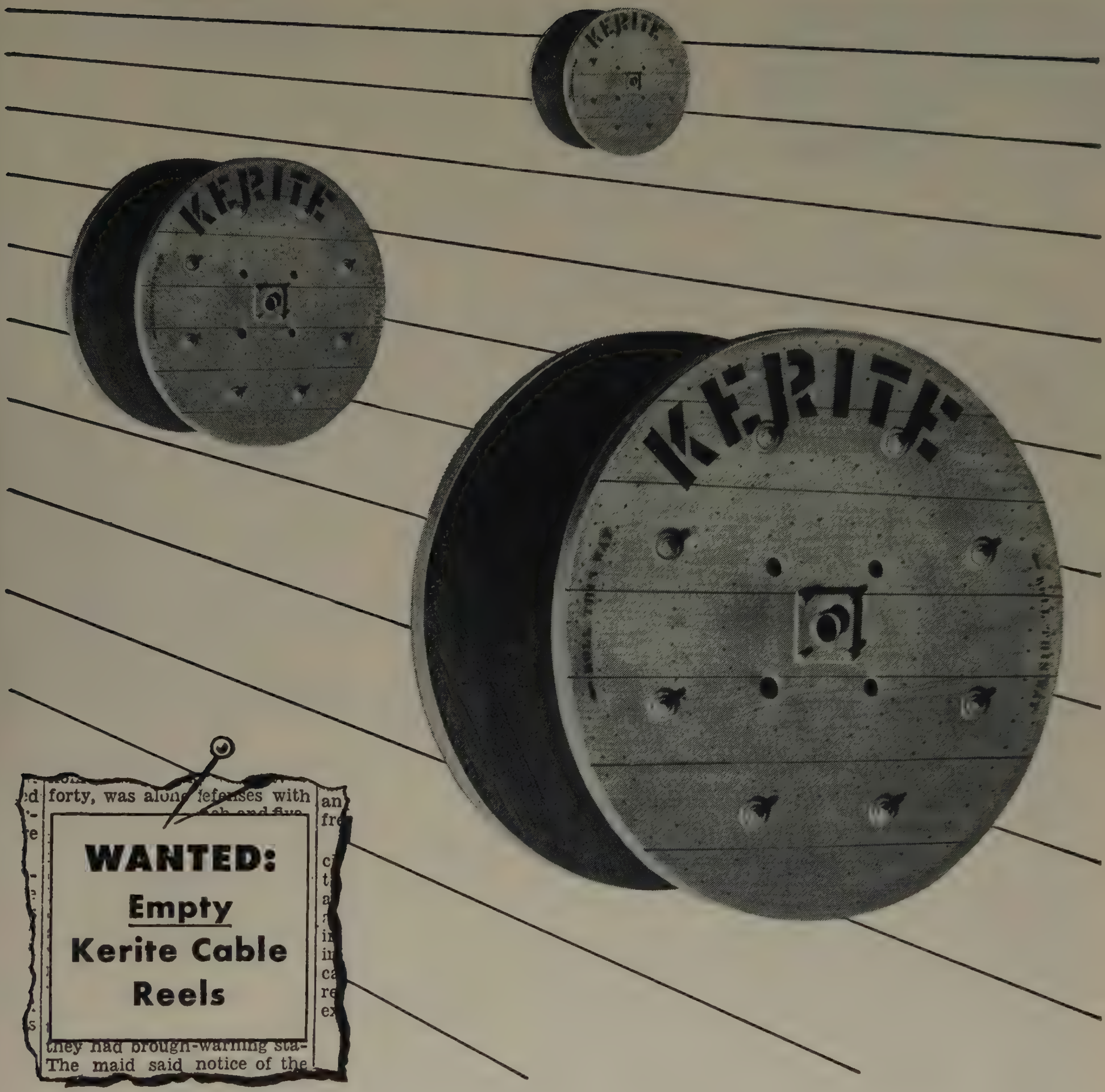
One of the Big 3 in Electric Power Equipment — Biggest of All in Range of Industrial Products



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Kerite Cable

Reels

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The maid said notice of the

KERITE is, regretfully, forced to ask your help in rounding up and returning to us, as soon as possible, all available KERITE cable reels which you can spare.

Shortages of materials for reels makes this request necessary.

Happily we are still able to turn out record quantities of KERITE cable — but unless the reel problem is solved quickly, we will be unable to make deliveries as fast as we can complete production of your orders.

Please bring this matter to the attention of the proper people in your organization so that we can continue to serve you to the best of our ability.

Reels should be returned to The Kerite Company, Seymour, Conn.

Kerite Insulation—Your Cable's Best Life Insurance

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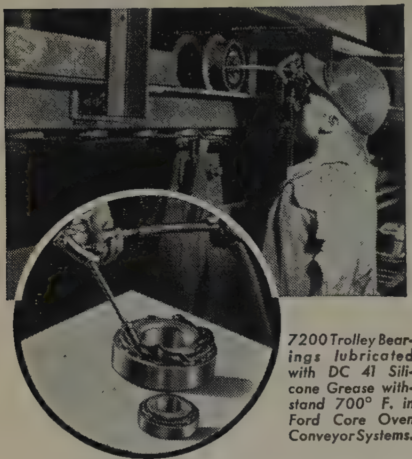
Silicone News

DC SILICONES

Ford Uses Silicone Grease in Bearings at 700° F.



7200 Trolley Bearings lubricated with DC 41 Silicone Grease withstand 700° F. in Ford Core Oven Conveyor Systems.

PHOTO COURTESY FORD MOTOR COMPANY

The cost of designing around the thermal limitations of organic greases is often prohibitive. In such cases, frequent relubrication, high maintenance costs, and production stoppages were inevitable until Dow Corning introduced a line of semi-inorganic silicone greases serviceable at temperatures far above the limits of organic greases.

The economy of this new solution to high temperature lubrication problems is demonstrated in the core oven conveyor systems operated by the Ford Motor Company. These core ovens operate 16 hours a day, 5 days a week, at a peak heat of 700° F. The 7200 trolley bearings are exposed to such temperatures for 2½ hours out of every 4 hours. Even with automatic oiling, the bearings froze, wheels were flattened, and production was interrupted.

After careful testing, Ford's Chemical Engineering Department recommended DC 41 Silicone Grease. Lubricated with this heat-stable silicone grease, the conveyor systems require considerably less power to operate. They start easily and run continuously. Replacement and maintenance costs are greatly reduced and the bearings exposed to 700° F. are relubricated only once a week.

If you have a high temperature or permanent lubrication problem, write for Dow Corning Silicone Grease data sheet No. A 7-2 or call our nearest branch office.

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FIRST IN SILICONES

INDUSTRIAL NOTES ....

Lincoln Electric Appointment. G. F. Clipsham has been appointed to the position of assistant to the president of the Lincoln Electric Company, Cleveland, Ohio.

New Office. As part of a national program of expanded local coverage to take care of the increase in installment sales paper from General Electric and Hotpoint appliance dealers, the General Electric Credit Corporation has opened a new office in Oklahoma City, Okla. H. S. Sherman has been appointed manager of the office, located at 105 North Hudson Street.

Management Change. Charles S. Munson, formerly president of Air Reduction Company, Inc., has been elected chairman of the executive committee. He is succeeded by John A. Hill, who becomes the fifth president of the company. William C. Keeley, formerly vice-president, was elected chairman of the newly created finance committee. C. E. Adams remains chairman of the board of directors.

Pennsalt Plant. The Pennsylvania Salt Manufacturing Company announced recently that it will build a new flourine chemicals plant near Paducah, Ky. The new plant is expected to fill Pennsalt's requirements for additional facilities for its expanding production of fluorine chemical products. Construction will start in the near future and the first unit of the plant is expected to be completed by February 1949. The new plant ultimately may include other products and is expected to be one of Pennsalt's largest.

Dissolution. Selenium Corporation of America, an affiliate of Vickers Inc., of Detroit, Mich., and a unit of the Sperry Corporation, has been dissolved voluntarily, effective December 31, 1947. The company is succeeded by Vickers Electric Division, Vickers Inc., 2160 East Imperial Highway, El Segundo, Calif.

American Relay Purchased. American Relay and Controls, Inc., 2555 West Diversey Avenue, Chicago, makers of electric relays, switches, and specialized controls, has been purchased by David T. Siegel, Chicago manufacturer. The firm has moved to a new location at 4900 West Flournoy Street, Chicago 44, Ill.

Director Elected. Robert Heller, industrial engineer and head of Robert Heller and Associates, has been elected a director and member of the executive committee of Jack and Heintz Precision Industries, Inc., Cleveland, Ohio.

Westinghouse Purchases. The Westinghouse Electric Corporation has announced the purchase of additional manufacturing facilities in western Pennsylvania near Irwin, Pa., as part of a $132,000,000 long-range company-wide expansion and improvement program. The purchase consists of 20 acres of land and four 3-story buildings at Hahntown, two miles south of Irwin.

New Corporation. Rowe Radio Research Laboratory of Chicago announced the formation of Rowe Engineering Corporation, under which name all new business will be transacted hereafter. Rowe Radio, however, will continue to operate simultaneously, probably through 1948, until several large government contracts are completed. Officers of the newly formed Rowe Engineering Corporation are: Henry Charles Rowe, president and director of engineering; Robert P. Faust, vice-president in charge of sales; S. Charles Kohl, secretary and treasurer; and Dwight V. Sinninger, chief engineer. All of these men also are directors of the corporation. The address is 2422 North Pulaski Road, Chicago 39, Ill.

IT&T Consolidation. International Telephone and Telegraph Corporation announces that the consolidation of its manufacturing activities through the acquisition of International Standard Electric Corporation, N. Y. by Federal Telephone and Radio Corporation, Clifton, N. J., has been approved by the board of directors. Both companies are IT&T subsidiaries. Through the acquisition of the stock of ISE, the Federal will control the major manufacturing subsidiaries of the IT&T system throughout the world, including more than 30 plants in 24 countries.

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NBS Appointment. Russell E. Dorrell has been appointed to the staff of the National Bureau of Standards. He will be with the electron tube laboratory as an electronics engineer, where he will aid in the development, improvement, comparison, and standardization of test methods and equipment for evaluating tube performance.

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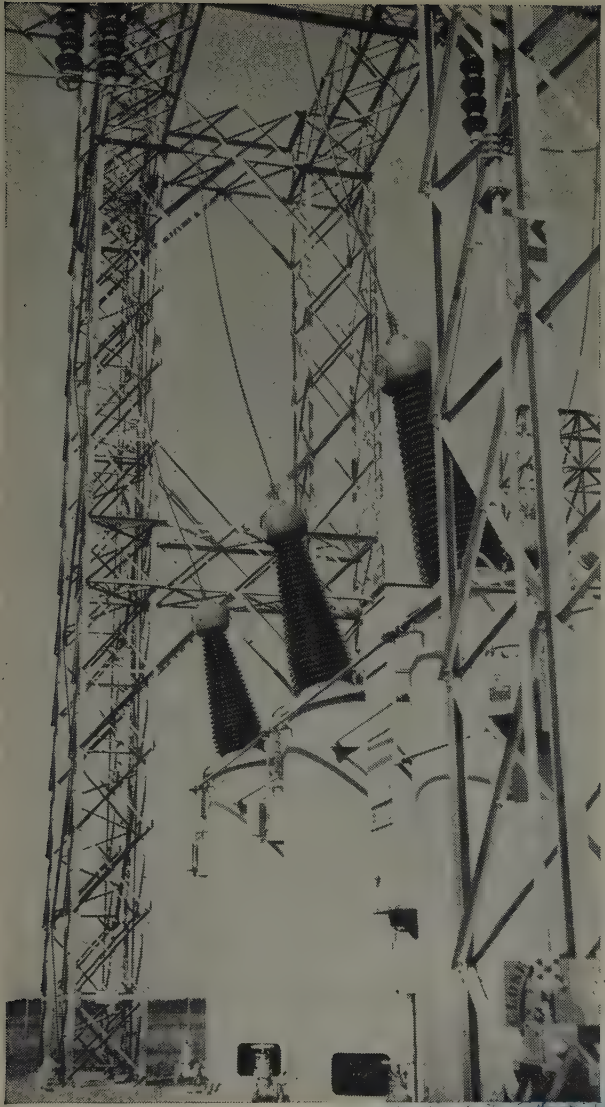
(*Continued on page 34A*)



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Canadian Ohio Brass Co., Ltd., Niagara Falls, Ontario

20 years' experience with O-B guides this

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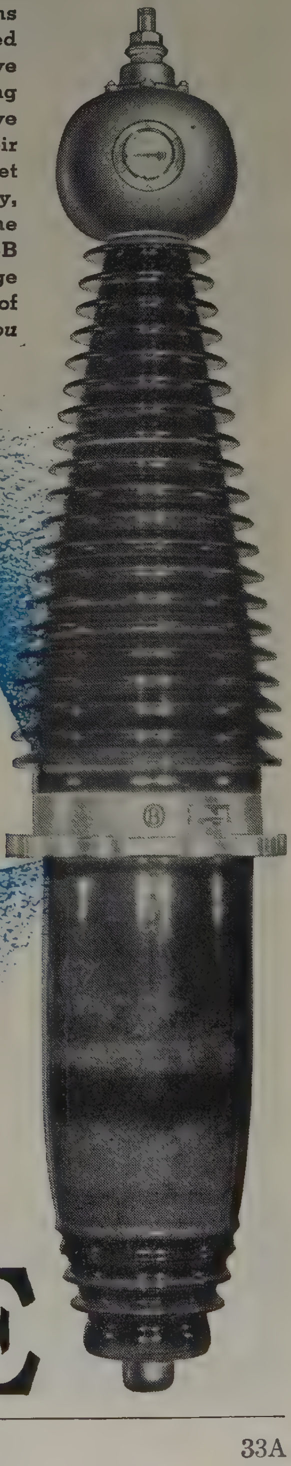


WHEN *Precision* IS PRIMARY

INSIST ON *Vallorbs*

for Industrial Jewel Bearings with accurate tolerances, micro smoothness and long wearing qualities in Sapphire, Ruby and Garnet. Vallorbs has both the equipment and capabilities for fabricating Industrial jewels, intricate metal stampings and Swiss screw machine products to rigid tolerances. We invite your inquiries—with or without drawings—for careful consideration and prompt response.

THE VALLORBS JEWEL COMPANY
LANCASTER, PA., U. S. A.

(Continued from page 14A)

TRADE LITERATURE

Wrench Line. Catalogue number 247, 36 pp. Lists socket, box-type, and open-end wrenches and sets, including new "Nugget" double-duty drive socket wrenches. Blackhawk Manufacturing Company, Milwaukee 1, Wis.

Marine Radar. Booklet *B-3845-A*, 8 pp. Installation views of radar equipment and actual radar scope photographs taken at strategic points in Chesapeake Bay, the Great Lakes, and the Neches River near Port Arthur, Tex., are contained in the booklet. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

Cathode Press. The *Cathode Press* published quarterly by Machlett Laboratories, Inc., Springdale, Conn., is a house organ, the purpose of which is to report the role Machlett is taking in the development of new products, improvement of current models, and their application.

Selection Chart. A guide for the selection of induction heating and melting equipment has been made available without charge by the Ajax Electrothermic Corporation, Trenton 5, N. J. It includes ratings for motor generator, mercury-hydrogen spark-gap, quenched gap, and vacuum tube types of equipment.

Self-Priming Pump. Bulletin 08B6319B. Allis-Chalmers automatic self-priming pump equipped with a new type automatic spring valve said to give faster, smoother, transition from priming or vacuum pumping to straight centrifugal action, is described in an 8-page illustrated bulletin. Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

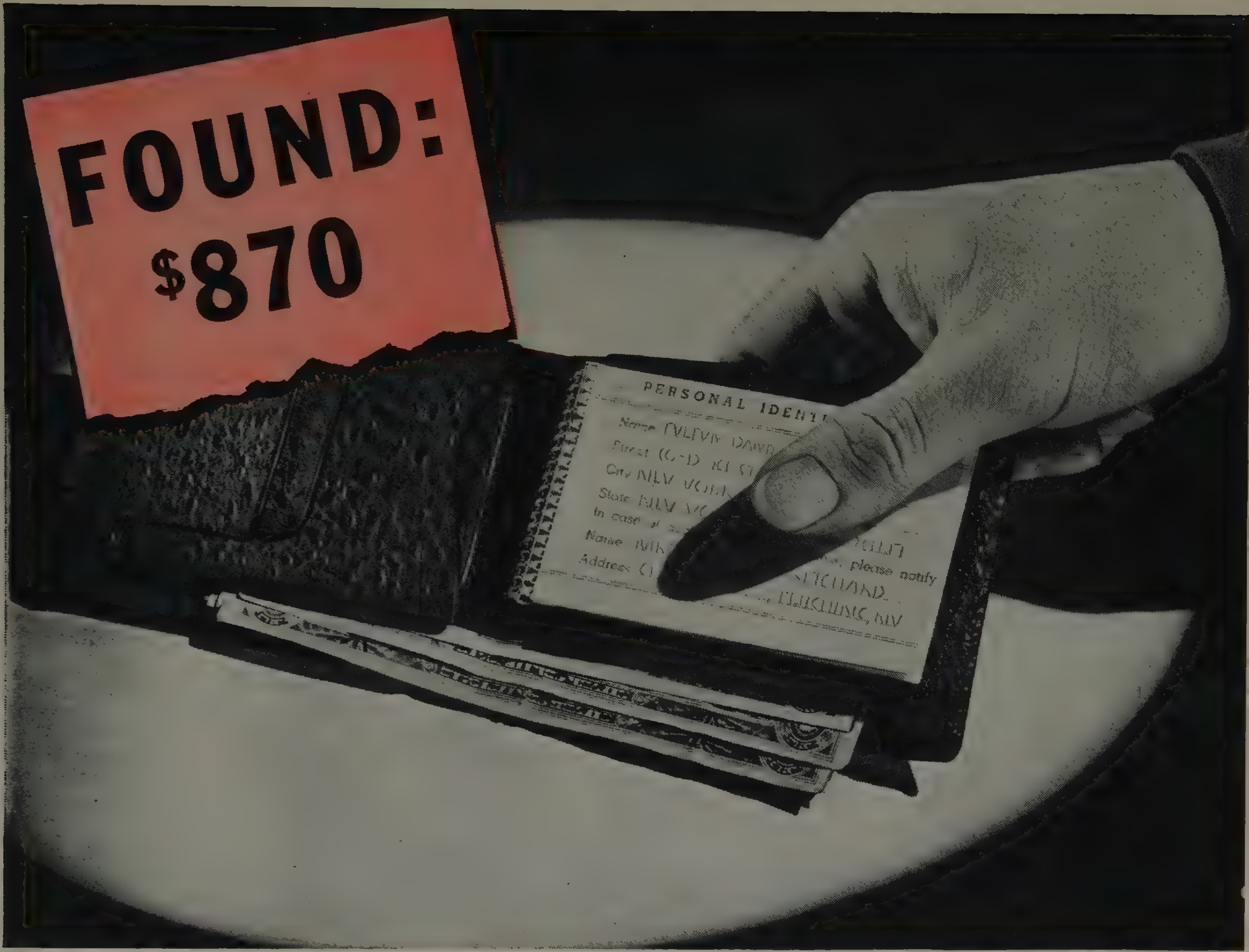
Photographic Paper. Kodagraph Autopositive paper, a silver sensitized paper for reproducing engineering drawings, is described in an 8-page pamphlet available from the Industrial Photographic Division, Eastman Kodak Company, 343 State Street, Rochester 4, N. Y.

High Current Resistors. Bulletin No. 35. This bulletin illustrates and describes the various types of ribbon resistors available for high current applications. It contains also data relating to their resistance values, current carrying capacities, dimensions, methods of mounting, and so forth. Ward Electric Company, 31 South Street, Mount Vernon, N. Y.

Ball Bearings. Catalog No. 6. This booklet describes the installation, lubrication, and removal of miniature ball bearings. Landis & Gyr, Inc., 104 Fifth Avenue, New York 11, N. Y.

Tubular Trimmer. Types 531 and 532 tubular trimmer have low minimum capacity, high ratio of tuning range, require little space. Capacity range is 1–8 micro-

(Continued on page 58A)



An example of how carbon-brush standardization paid a large company

A LARGE industrial company had been ordering 12 types of carbon brushes for one type of motor, in small lots of 25 to 450. By utilizing the brush-standardization methods recommended by National Carbon Company, Inc., it was found that *one* type of brush could be used on all the motors. This company then ordered their annual supply of 6000 carbon brushes for this type of motor in 3000-item lots and saved $870 — simply by buying in more economical quantities.

If you use carbon brushes — just a few or many thousands — you can save time and money by writing to National Carbon Company for detailed recommendations on how to simplify brush stocks. Or, if you prefer, call in a National Carbon Company representative for on-the-job consultation.

HOW BRUSH STANDARDIZATION PAYS

1. Permits buying in economical quantities.
2. Fewer small orders—with savings in bookkeeping, billing, and accounting.
3. Less money and space tied up in brush stocks.
4. Less time needed to handle stock.

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These books furnish much of the authoritative information necessary to keep abreast of present-day progress in electrical engineering. Make your selection and order from the coupon today.

BATTLEFRONTS OF INDUSTRY
By David O. Woodbury

The dramatic story of Westinghouse Electric's contribution to the war effort. The book stresses the ingenuity of engineers and scientists in developing and completing assignments which had been considered impossible in peacetime. It explains how the application of mass production techniques made possible the speedy completion of war machines. The role of research in winning the war is also discussed.
1948 329 pages $3.50

VACUUM TUBE CIRCUITS
By Lawrence B. Arguimbau
A carefully developed study of simple and complex circuits designed to cover problems encountered by communications technicians. Includes chapters on radio communication; diodes and rectifiers; triodes, pentodes and linear amplifiers; and television.
1948 668 pages $6.00

POWER SYSTEM STABILITY
Volume I
By Edward W. Kimbark
Presents methods of analysis and calculation necessary to determine the stability of a given system when subjected to a specified disturbance. Examines the effect of various factors on stability and outlines measures for improving stability.
1948 356 pages $6.00

ELECTRONIC TRANSFORMERS AND CIRCUITS
By Reuben Lee
For use and reference by radar, communications and electronic engineers. Contains information on the design of transformers for electronic apparatus, and the effects of transformer characteristics on electronic circuits.
1947 284 pages $4.50

ELECTRONICS FOR INDUSTRY
By Waldemar I. Bendz, assisted by Charles A. Scarlott
Describes various types of electronic tubes, their functions, and the basic circuits in which they are used in industrial devices.
1947 501 pages $5.00

ULTRAHIGH FREQUENCY TRANSMISSION & RADIATION
By Nathan Marchand
Presents basic principles of UHF for ready application to problems in mobile and relay communications, frequency modulation, relay and color television, and pulse time modulation. M.K.S. units are used throughout.
1947 322 pages $4.50

HEAT PUMPS
By Philip Sporn, E. R. Ambrose, and Theodore Baumeister
Describes the use of heat pumps for building heating and cooling services, in evaporation and purification of liquids, drying of solids, and simultaneous chilling and heating of process fluids.
1947 188 pages $3.75

ELECTRIC MOTOR MAINTENANCE
By W. W. McCullough
Discusses the construction of various motors, and outlines methods used to test them. Fully describes cleaning and drying of motors, and recommends tools to be used in maintenance and repair of motors.
1947 126 pages $2.00

POWER SYSTEM STABILITY
By Selden B. Crary
Volume I, Steady State Stability
For power system and apparatus design engineers. Outlines modern methods of analyzing power system problems.
1945 291 pages $4.00
Volume II, Transient Stability
Discusses such factors affecting performance as occurrence, types and locations of short circuits, and the response of the system to sudden changes in voltage and current.
1947 342 pages $6.00

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Please send me, on ten days' approval, the books I have checked in this advertisement (or I am attaching to this coupon a separate list of the books I want). At the end of that time, if I decide to keep the books, I will remit indicated price plus postage; otherwise I will return the books postpaid.

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(Continued from page 36A)

microfarads; power factor 0.1 per cent maximum: rated voltage 350 volts direct current; dimensions approximately three-eighths of an inch diameter by $1^5/_{16}$ inch long at maximum capacity. Type 531 is for panels 0.015 inch to 0.039 inch thick; type 532 is for panels 0.040 inch to 0.065 inch thick. Additional information may be obtained from the Erie Resistor Corporation, 640 West 12th Street, Erie, Pa.

Generator Sets. An 8-page illustrated bulletin on Superior Diesel generator sets, ranging in size from 175 to 1,500 horsepower, describes and gives dimensions and specifications for the various models which include supercharged and nonsupercharged 6- or 8-cylinder sets. Ratings of generators are from 120 kw to 1,055 kw. Bulletin may be obtained by writing to the Superior Engine Division, The National Supply Company, Springfield, Ohio.

V-Belt Catalogue. A new V-belt catalogue containing comparison tables, selection data, and other detailed information on V-belts for electric refrigerators, home workshop equipment, ironers, farm appliances, and other devices has been issued by the United States Rubber Company, 1230 Avenue of the Americas, New York 20, N. Y.

NEW PRODUCTS • • • •

Weatherproof Socket. Neoline, Inc., 130 South Hewitt Street, Los Angeles 12, Calif., is introducing the Neolite Weatherproof Socket 350 which is said to achieve positive proofing against weather, water, and vapor through sealing with Neoprene, a crackproof, crushproof, elastic composition that is completely resistant to water, oil, heat, and cold. The phosphor spring bronze contact of the socket is embedded in Neoprene threads, while a moisture-tight lip of Neoprene seals the globe, and the 6-inch pigtail outlets are moulded into the Neoprene Base. No parts are exposed.

High-Speed Electric Impact Nut Setter. Faster, easier on the operator, lightweight, heavy duty, high-speed, portable—these are the chief features claimed for the Speed-O-Matic electric torqueless impact nut setter. Additional information may be obtained from the manufacturer, Illinois Gage and Manufacturing Corporation, 4639 West Washington Boulevard, Chicago 44, Ill.

Flexarc LoH Electrode. A hydrogen-free mineral-type extrusion-coated electrode that is said to eliminate "underbead cracking" is available from Westinghouse Electric Corporation, Pittsburgh, Pa. Ranging in diameter from 1/4 inch to 1/8 inch, these electrodes are recommended for use with d-c reverse polarity and also for alternating current.

HIGHLIGHTS........

AIEE Meetings. Student attendance was particularly heavy at this year's Great Lakes District meeting, held in Des Moines, Iowa, April 1–3. This is the first meeting to be held so far west in District 5 (*pages 498–9*). The Midwest general meeting will be held this year in Milwaukee, Wis., October 18–22 (*page 492*), and general committee personnel for the meeting has been announced (*page 490*). The dates and site for the 1948 Pacific general meeting have been announced as August 24–27 in Spokane, Wash. (*page 489*). The North Eastern District meeting will be reported in the next issue.

AIEE Conferences. The first of a new type of AIEE national meeting, the AIEE conference, was held in Philadelphia, Pa., March 29–30. The subject was electron tubes for instrumentation and industrial use (*page 494–7*). The second of these conferences, on electrical engineering aspects in the rubber and plastics industries, was held on April 20 in Akron, Ohio, and will be reported in *ELECTRICAL ENGINEERING* for June.

Summer Meeting in Mexico. With the latest trends and practices in the development of electric power in Mexico's industries as its theme, the 1948 summer general meeting will open at Mexico City's Teachers' College on June 21 (*page 486*). An invitation to attend the meeting, and to become acquainted with the people and customs of Mexico, is extended by the Mexico Section (*page 490*). The complete technical program for the meeting as it stands at the present writing is included in this issue (*pages 488–9*), as well as a schedule of events and a schedule of inspection trips (*page 487*). For the information of those who expect to attend the meeting, short descriptions of spots of interest in and near Mexico City are presented (*pages 486–7, 489*).

Board of Directors. A number of amendments to the AIEE constitution, proposed by the committee on constitution and bylaws, were approved for submission to the membership for vote at the meeting of the AIEE board of directors held on January 29, in Pittsburgh, Pa., during the 1948 winter general meeting of the Institute. Other actions taken included authorization of future meetings, changes in Section territories, and establishment of a new committee (*pages 492–3*).

Digests. The new type of digest which has replaced the abstract (*EE, Apr '48, p 378*) makes its first appearance in this issue (*pages 435, 440, 445, 451, 455, 475, 476*).

Future Power Needs. "If the United States is to progress as a nation, the nation's productivity must increase, and to do this even more horsepower must be placed behind the worker." Thus, it is evident that the steady advance in the application of electric power to industry in the last 20 years will become even more pronounced in the future, and the attendant engineering problems even more difficult (*pages 477–82*).

Air Safety. The fliers' slogan that aviation in itself is not dangerous, but . . . is unforgiving of any carelessness or neglect well can be extended to include "that aviation is unforgiving of ignorance or disregard of nature's laws and, especially, of the destructive caprices of uncontrolled or unrecognized electrostatic hazards—the consideration of which is the subject of this article" (*pages 423–9*).

Isotope Separation. The separation of isotopes from a mixture containing more than one isotope of a substance can be accomplished by several methods. Although all the methods are not practical for mass production, an understanding of the theory will contribute to fundamental knowledge of nuclear behavior. This is the sixth of a series of articles developed by the AIEE nucleonics committee to provide a necessary background in this increasingly important field. At the conclusion of the series, a consolidated pamphlet of reprints including the entire series will be available to interested readers (*pages 469–74*).

New Insulation Described. A counterpart of the numerous organic sheet and tape insulations has developed for class *B* use. Terratex is made from asbestos fiber by a special paper-making process on fairly standard paper-making machines. The resulting sheet, which has found numerous uses in electric apparatus, is thin, flexible, 100 per cent inorganic, and very similar in appearance to cellulosic paper (*pages 452–4*).

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Microwave Calibrations. The National Bureau of Standards has completed a microwave frequency standard which provides continuous frequency coverage from 300 to 30,000 megacycles. There is also provision for the generation of spot frequencies of highest precision at approximately 1-per-cent intervals over the same band of frequencies (*pages 436–9*).

X Rays Gauge Hot Steel. A recently developed X-ray thickness gauge for hot strip rolling mill application uses one X-ray source and two photoelectric multiplier pickup units. Operation is such that the photoelectric detectors compare the received signals with internally generated reference signals and indicate the difference. The indicator unit shows both standard gauge being run and deviation from gauge thickness (*pages 441–4*).

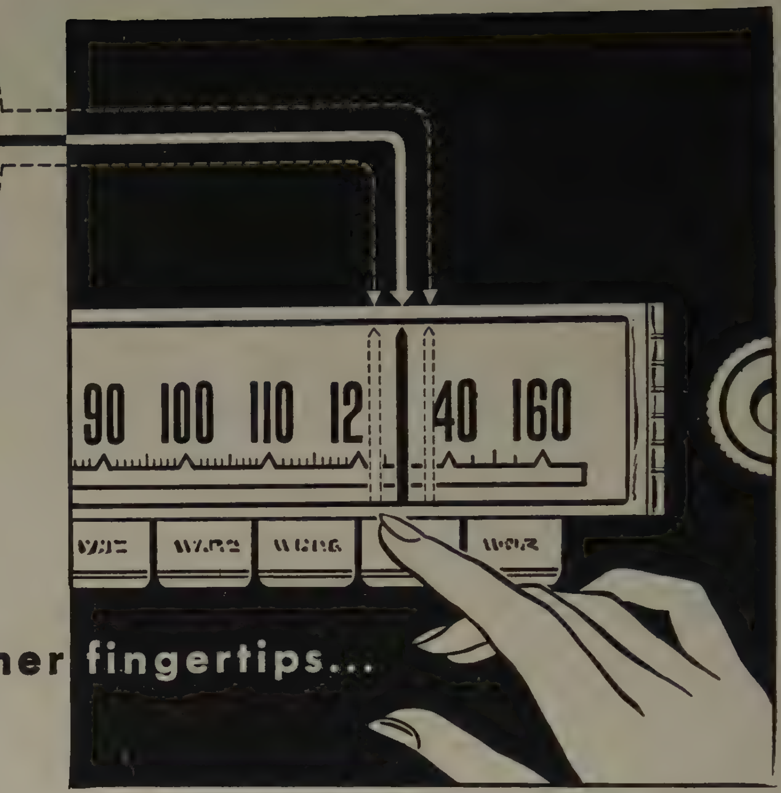
Energy Source. As one of a series of articles reviewing known sources of electric power, this 2-part article covers the electrochemical source, or battery. Part 2 of the article, appearing in this issue, describes the technical aspects of the subject (*pages 456–65*).

Reactance Formulas Compared. The leakage reactance of induction motors has been calculated by various methods, each of which has been discussed widely in AIEE literature. To determine how design engineers resolved the problem and how well they are able to match their design calculations to motor test performance, the design data of 2-horsepower squirrel-cage induction motor were given to a group of motor designers. The calculations of these men are compared with the results of tests on the motor (*pages 430–4*).

New-Type A-C Bus. A revolutionary aluminum bus for inside distribution of large blocks of a-c power has been designed using a modified triangular configuration. Preliminary tests show that it is an improvement over previous designs in weight and space, and at least equals the others in considerations of voltage drop, cost, ease of alteration, and safety to personnel (*pages 448–50*).

Telemetering Devices. Two auxiliary devices have been derived from the torque balance telemeter which greatly will broaden the field of application by providing the additional functions of signaling and the totalizing and integrating of a telemetered quantity (*pages 483–5*).

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices 500 Fifth Avenue, New York 18, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P.L. &. R. Act of February 28, 1925. May 1948, Vol. 67, No. 5. Number of copies of this issue 45,000



STRAIGHT LINE TRACKING at her fingertips...

A station comes in at the number it's supposed to . . . IF the tuner gives straight line tracking.

To get perfect tracking — straight line tracking — in your inductance tuners, the electrical characteristics of the cores have to be *uniform throughout the entire core-length.*

But a core can be no more uniform than the powder it's made of. That's why it's important to use the uniquely uniform G. A. & F. Carbonyl Iron Powder.

Made with great care — and by G. A. & F.'s exclusive, patented carbonyl process — G. A. & F. Carbonyl Iron Powders are uniform, not only within a batch, but from one batch to another. For example, the permeability of different batches over a period of years has been held *within plus or minus one percent.*

G. A. & F. Carbonyl Iron Powders for high frequency cores offer these advantages to the electronics industry:

1. When used at radio frequency, G. A. & F. Carbonyl Iron Powders are superior in coefficients of eddy current loss and residual loss. These low losses make for higher Q.

2. G. A. & F. Carbonyl Iron Powders stand alone in co-efficients of magnetic and temperature stability.

3. In comparison with air-cored coils, G. A. & F. Carbonyl Iron Powder-cored coils permit savings in volume, weight, and wire-length, along with great increases in inductance and Q.

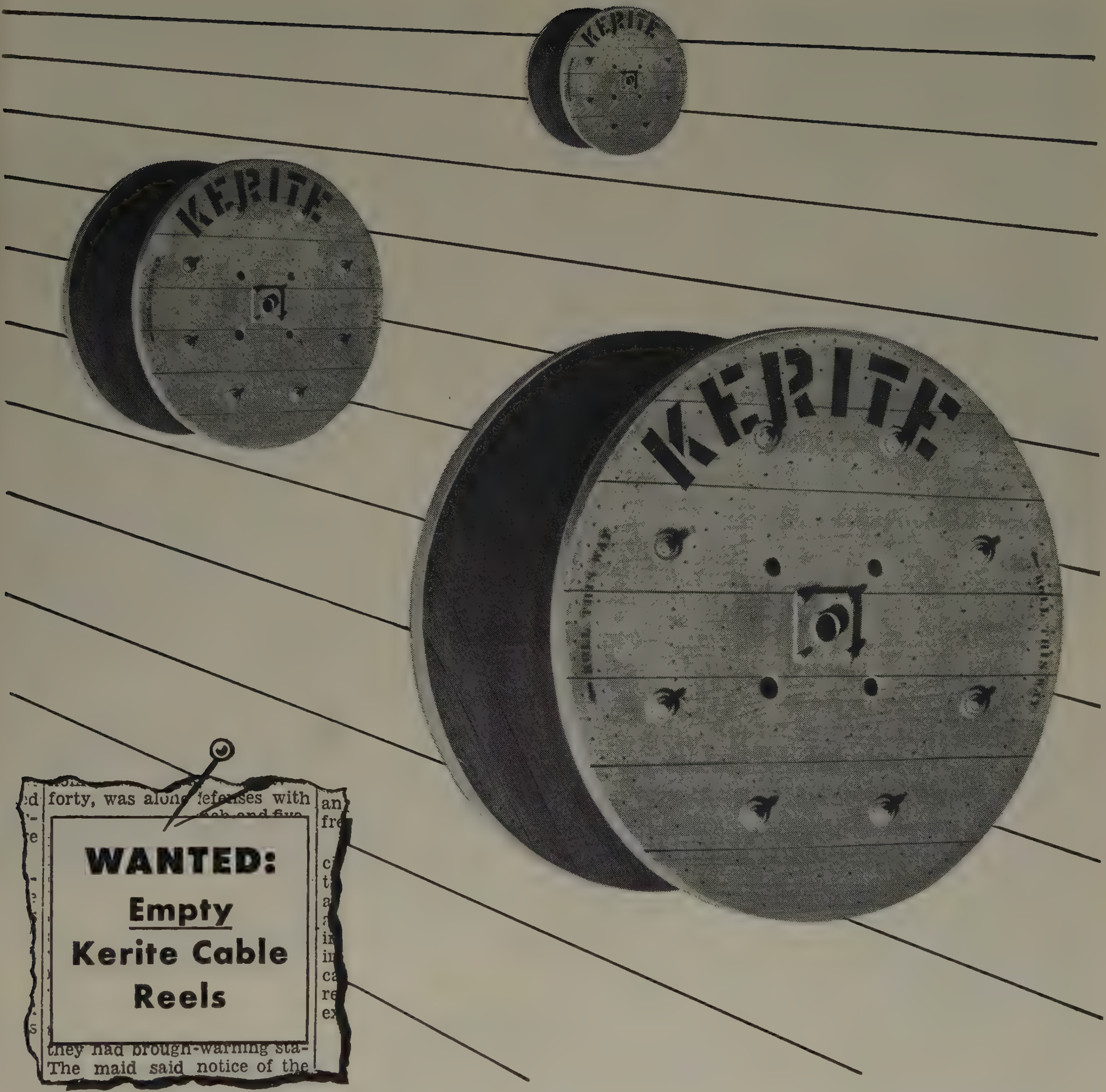
➡ Ask your core manufacturer for information about G.A.&F. Carbonyl Iron Powders. Or write direct to: Antara Products, 444 Madison Avenue, New York 22, N. Y. Dept. 51.

These unique properties tell why G. A. & F. Carbonyl Iron Powders are superior:

PROPERTY	ADVANTAGE
Spherical structure	Facilitates insulation and compacting
Concentric shell structure (some types only)	Low eddy current losses
High purity	Exceptional permeability and compressibility
Absence of non-ferrous metals	Absence of corresponding disturbing influences
Relative absence of internal stress; regular crystal structure	Low hysteresis loss
Spheres of small size	Low eddy current losses; usable for high frequencies
Variations of sphere size	Extremely close packing

G. A. & F. CARBONYL IRON POWDERS

An Antara® Product of General Aniline & Film Corporation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KERITE
forty, was along defenses with
WANTED:
Empty
Kerite Cable
Reels
they had brough-warning sta-
The maid said notice of the

Kerite is, regretfully, forced to ask your help in rounding up and returning to us, as soon as possible, all available Kerite cable reels which you can spare.

Shortages of materials for reels makes this request necessary.

Happily we are still able to turn out record quantities of Kerite cable — but unless the reel problem is solved quickly, we will be unable to make deliveries as fast as we can complete production of your orders.

Please bring this matter to the attention of the proper people in your organization so that we can continue to serve you to the best of our ability.

Reels should be returned to The Kerite Company, Seymour, Conn.

Kerite Insulation—Your Cable's Best Life Insurance

KERITE CABLE

Silicone News

DC SILICONES

Ford Uses Silicone Grease in Bearings at 700° F.

7200 Trolley Bearings lubricated with DC 41 Silicone Grease withstand 700° F. in Ford Core Oven Conveyor Systems.

PHOTO COURTESY FORD MOTOR COMPANY

The cost of designing around the thermal limitations of organic greases is often prohibitive. In such cases, frequent relubrication, high maintenance costs, and production stoppages were inevitable until Dow Corning introduced a line of semi-inorganic silicone greases serviceable at temperatures far above the limits of organic greases.

The economy of this new solution to high temperature lubrication problems is demonstrated in the core oven conveyor systems operated by the Ford Motor Company. These core ovens operate 16 hours a day, 5 days a week, at a peak heat of 700° F. The 7200 trolley bearings are exposed to such temperatures for 2½ hours out of every 4 hours. Even with automatic oiling, the bearings froze, wheels were flattened, and production was interrupted.

After careful testing, Ford's Chemical Engineering Department recommended DC 41 Silicone Grease. Lubricated with this heat-stable silicone grease, the conveyor systems require considerably less power to operate. They start easily and run continuously. Replacement and maintenance costs are greatly reduced and the bearings exposed to 700° F. are relubricated only once a week.

If you have a high temperature or permanent lubrication problem, write for Dow Corning Silicone Grease data sheet No. A 7-2 or call our nearest branch office.

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INDUSTRIAL NOTES . . . .

Lincoln Electric Appointment. G. F. Clipsham has been appointed to the position of assistant to the president of the Lincoln Electric Company, Cleveland, Ohio.

New Office. As part of a national program of expanded local coverage to take care of the increase in installment sales paper from General Electric and Hotpoint appliance dealers, the General Electric Credit Corporation has opened a new office in Oklahoma City, Okla. H. S. Sherman has been appointed manager of the office, located at 105 North Hudson Street.

Management Change. Charles S. Munson, formerly president of Air Reduction Company, Inc., has been elected chairman of the executive committee. He is succeeded by John A. Hill, who becomes the fifth president of the company. William C. Keeley, formerly vice-president, was elected chairman of the newly created finance committee. C. E. Adams remains chairman of the board of directors.

Pennsalt Plant. The Pennsylvania Salt Manufacturing Company announced recently that it will build a new flourine chemicals plant near Paducah, Ky. The new plant is expected to fill Pennsalt's requirements for additional facilities for its expanding production of fluorine chemical products. Construction will start in the near future and the first unit of the plant is expected to be completed by February 1949. The new plant ultimately may include other products and is expected to be one of Pennsalt's largest.

Dissolution. Selenium Corporation of America, an affiliate of Vickers Inc., of Detroit, Mich., and a unit of the Sperry Corporation, has been dissolved voluntarily, effective December 31, 1947. The company is succeeded by Vickers Electric Division, Vickers Inc., 2160 East Imperial Highway, El Segundo, Calif.

American Relay Purchased. American Relay and Controls, Inc., 2555 West Diversey Avenue, Chicago, makers of electric relays, switches, and specialized controls, has been purchased by David T. Siegel, Chicago manufacturer. The firm has moved to a new location at 4900 West Flournoy Street, Chicago 44, Ill.

Director Elected. Robert Heller, industrial engineer and head of Robert Heller and Associates, has been elected a director and member of the executive committee of Jack and Heintz Precision Industries, Inc., Cleveland, Ohio.

Westinghouse Purchases. The Westinghouse Electric Corporation has announced the purchase of additional manufacturing facilities in western Pennsylvania near Irwin, Pa., as part of a $132,000,000 long-range company-wide expansion and improvement program. The purchase consists of 20 acres of land and four 3-story buildings at Hahntown, two miles south of Irwin.

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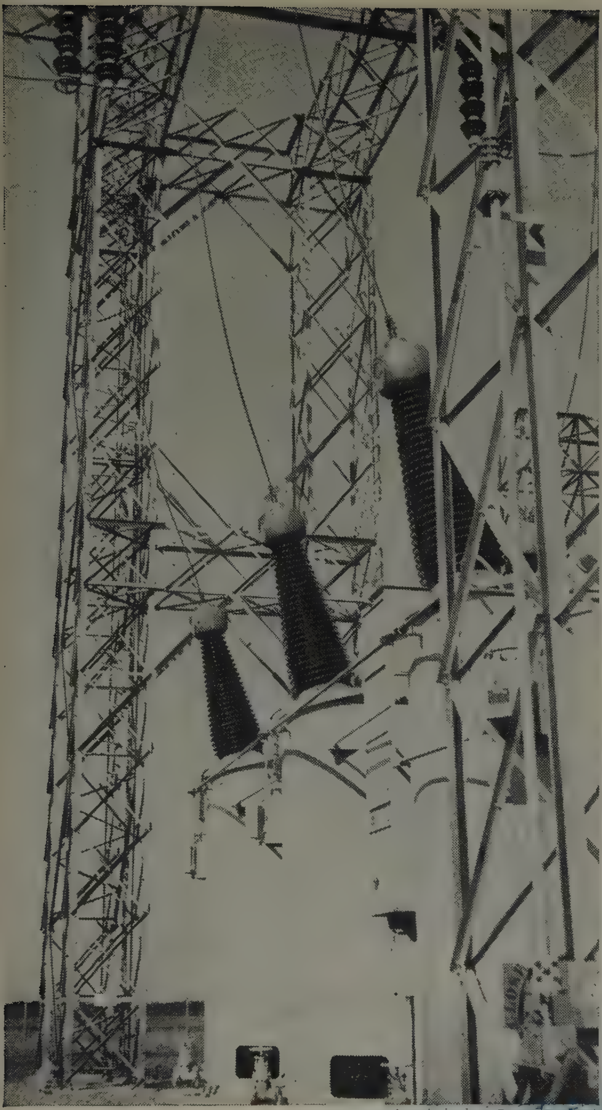

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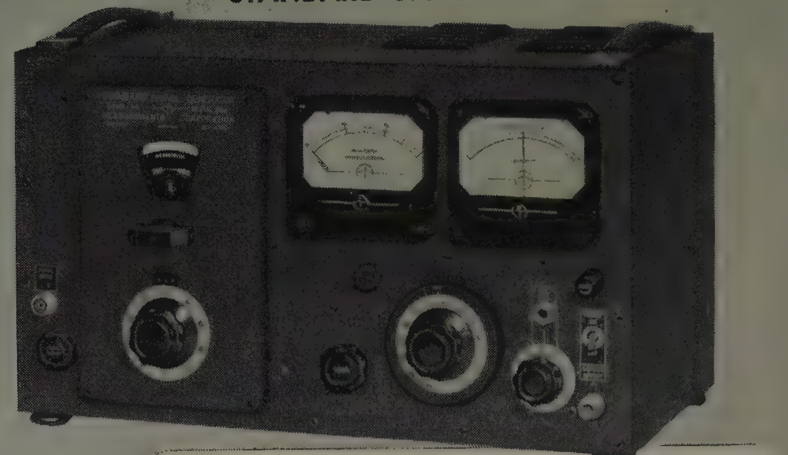
20 years' experience with O-B guides this BUSHING PREFERENCE

MEASUREMENTS CORPORATION *MODEL 80*

STANDARD SIGNAL GENERATOR



2 to 400 MEGACYCLES

MODULATION: Amplitude modulation is continuously variable from 0 to 30%, indicated by a meter on the panel. An internal 400 or 1000 cycle audio oscillator is provided. Modulation may also be applied from an external source. Pulse modulation may be applied to the oscillator from an external source through a special connector. Pulses of 1 microsecond can be obtained at higher carrier frequencies.

FREQUENCY ACCURACY ±.5%

OUTPUT VOLTAGE
0.1 to 100,000 microvolts

OUTPUT IMPEDANCE
50 ohms

MANUFACTURERS OF
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- Pulse Generators
- FM Signal Generators
- Square Wave Generators
- Vacuum Tube Voltmeters
- UHF Radio Noise & Field Strength Meters
- Capacity Bridges
- Megohm Meters
- Phase Sequence Indicators
- Television and FM Test Equipment

MEASUREMENTS CORPORATION
BOONTON NEW JERSEY

National
insulating materials

A COMPLETE SERVICE

Research and field experience by the builders of NATIONAL Coils has resulted in the development of superior insulating materials.

Insulating materials that assure long life and trouble-free service when used in your electrical equipment, are available from NATIONAL.

NATIONAL is the complete source of all your insulation needs.

RAPID delivery from large stocks.

NATIONAL Insulation Engineers are near you—call one.

- Varnished Fabrics
- Tapes
- Sleevings
- Tubings
- Cords
- Twines
- Mica
- Papers
- Fibers
- Varnishes
- Cements
- Compounds
- Laminates

NATIONAL ELECTRIC COIL COMPANY
COLUMBUS 16, OHIO, U. S. A.
ELECTRICAL ENGINEERS MAKERS OF ELECTRICAL COILS AND INSULATION
TRADE MARK
REDESIGNING AND REBUILDING OF ROTATING ELECTRICAL MACHINES

(*Continued from page 14A*)

frequency heating equipment and RCA metal detectors in addition to its own regular line of electronic heating equipment. At the same time each of these companies will continue its research, engineering, manufacturing, and other normal activities in the field of electronics.

Acquisition. Stone and Webster, Inc., has acquired E. B. Badger and Sons Company for the purpose of expanding the engineering and construction activities of its subsidiary, Stone and Webster Engineering Corporation, in the process and industrial fields.

Sylvania Appointment. George R. Sommers, formerly Pacific Coast manager of lighting products for Sylvania Electric Products Inc., has been appointed director of sales for all product divisions of the company in that area.

Elmira-GE Apparatus Department. The Elmira Foundry Company Inc., of Elmira, N. Y., has been made an integral part of the General Electric Company. Dissolution of the corporation, heretofore a General Electric affiliated company, became effective January 2. Under the reorganization, the foundry becomes one of the nine major works and 24 factories composing the apparatus department.

Moves. The New York office of C. P. Clare and Company, has moved from its present quarters to suite 310 in the same (Graybar) building, at 420 Lexington Avenue. The company's present telephone number will remain unchanged.

New Plant. Camcar Products Company of Rockford, Ill., announces the completion of its new 1-story plant for the manufacture of special and standard screw products.

Millionth Motor. The millionth motor produced by Jack and Heintz Precision Industries, Inc., Cleveland, Ohio, rolled off the company's Berea Road plant assembly lines on January 9. Motor production in 1947 totaled 885,946, against a 1946 aggregate of 102,697.

Appointment. Joseph H. Gillies, who has been vice-president in charge of radio production since 1942, has been appointed vice-president in charge of radio division operations of Philco Corporation, Philadelphia, Pa.

Pioneer Acquisition. Pioneer Service and Engineering Company, a recently organized Illinois corporation, has announced the acquisition of the assets and business of Public Utility Engineering and Service Corporation, effective January 1, 1948.

Receiving Tube Sales. Almost 200 million radio receiving tubes were sold by Radio Manufacturers Association member-

(*Continued on page 40A*)

Give your transmission lines the sure and permanent protection that Copperweld Overhead Ground Wires afford. Every wire in the strand is permanently protected against corrosion by a thick covering of copper inseparably molten-welded to a tough alloy steel core. This insures rugged strength that is permanent—permits stringing with small sags—and provides ample mid-span clearance.

Thousands of important transmission lines, all over the world, are using Copperweld Overhead Ground Wires to insure dependable performance. You, too, can benefit by installing "Copperweld."

COPPERWELD STEEL COMPANY GLASSPORT, PA.
Sales Offices in Principal Cities

EVERY COPPERWELD WIRE COMBINES THE STRENGTH OF ALLOY STEEL . . . .
. . AND THE ELECTRICAL CONDUCTIVITY AND CORROSION-RESISTANCE OF COPPER.

Copperweld
NON-RUSTING
OVERHEAD GROUND WIRES

(*Continued from page 34A*)

companies in 1947, the RMA reported today. Receiving tube sales in December totalled 16,511,408 and brought total sales for the year to 199,533,827. This was slightly below the 205,217,174 tubes sold by manufacturers in 1946.

New Office. A branch office serving Wichita, Kans., and surrounding territory has been opened by the Minneapolis-Honeywell Regulator Company. The manager for the new branch, located at 1514 East Central, Wichita, is Lynn H. Johnson, Jr., who was sales manager of the company's gas controls division until his latest promotion.

NEW PRODUCTS • •

Constant Speed D-C Motor. A new model of its constant speed drive d-c motor has been announced by Amglo Corporation. The 1948 version is lighter and more compact than its predecessor and promises to find greater acceptance in industry for use in weather balloons and air-borne equipment and other similar applications where size and weight are factors that must be held to a minimum. The basic motor frame and aluminum reduction gearing occupies an area of $2^1/_2$ by $3^1/_2$ by $1^5/_8$ inches, small enough to fit in the palm of the hand. The weight is approximately ten ounces. The area and weight of cam and switching arrangements is additional. Inquiries and requests for information should be directed to A. F. Henninger, president, Amglo Corporation, 4234 Lincoln Avenue, Chicago 18, Ill.

GE Panel Instruments. A new line of $3^1/_2$-inch panel instruments of internal-pivot design, suitable for use in radio, power supplies, transmitters, amplifiers, and aircraft, has been announced by the meter and instrument divisions of the General Electric Company, Schenectady 5, N. Y. The new instruments, designated as type *DO-71*, have been designed especially for better readability. The elimination of arc lines and distracting printing from the scale, and the use of a lance-type pointer and large, clear numerals assure accurate readings.

Vertical Drive Unit. The newly available "vertical synchronous motor magnetic drive unit" is said to give smooth adjustable speed control for centrifugal pumps. The motor drives the ring of the magnetic drive at constant speed. Magnetic member of magnetic drive mounted on gear shaft operates the pump at speed required by liquid level control. Unit offers smooth, wide-range speed control, precludes "hunting," and eliminates frequent motor starts and stops. Electric Machinery Manufacturing Company, Minneapolis 13, Minn.

Multimeter. A multicombination meter, designed specifically for electrolysis and corrosion investigations and cathodic protection testing both in field and laboratory, has been developed and is now available. It provides all of the instrumentation required to cover the wide range of direct current and potential measurements necessary in this field. Full details can be secured from the manufacturer, M. C. Miller, 1142 Emerson Avenue, West Englewood, N. J.

Nu-Arc A-C Arc Welder. Simplified construction to increase the operating efficiency in the Nu-Arc a-c arc welder, redesigned with no moving parts, just has been announced by Electric Arc., Inc., Newark, N. J. The portable welder is built for general-purpose use in welding shops, industrial plants, shipyards, and railroad yards. It is a complete welding service, ready for immediate use. Additional information may be obtained from Electric Arc, Inc., 152–162 Jelliff Avenue, Newark 8, N. J.

New Battery Chargers. A line of small, light, portable battery chargers is introduced by Richardson-Allen Corporation of New York. Each unit features a meter which can be read while the battery is being charged, thus eliminating guesswork as to battery condition. Circuit breakers prevent the nuisance of blown fuses resulting from crossed wires. Models are available rated from 6 amperes to 80 amperes for average and fast charging. The chargers offer the ruggedness and de-

(*Continued on page 44A*)

2-inch wattmeter....
(Electrodynamometer Type)
Another Simpson First....
...for discriminating users of fine panel instruments
(ACTUAL SIZE)
Also available in various sizes and case styles. For complete information write for bulletin.
Simpson INSTRUMENTS THAT STAY ACCURATE
ELECTRIC COMPANY, 5200-5218 West Kinzie Street, Chicago 44, Illinois
In Canada, Bach-Simpson Ltd., London, Ont.

HERE'S HELP

in making HF, FM, and TV measurements

THE TYPE WV-75A VOLTOHMYST—
a new member of the famous RCA line

RCA HIGH-FREQUENCY VOLTOHMYST

. . . flat up to 250 megacycles!

- With diode probe, measures peak-to-peak voltages up to 250 megacycles. The High-Frequency (Advanced) VoltOhmyst is ideal for television, FM, and routine, high-frequency measurements. The diode response is also flat down to 30 cycles.

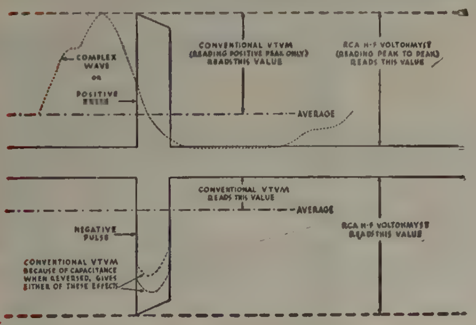
The WV-75A is calibrated in rms voltages up to 100 volts in 4 ranges. An adaptor is supplied for low-frequency measurements up to 1000 volts.

The WV-75A also measures d-c voltages up to 1000 volts in six ranges and resistances to 1000 megohms in six ranges.

• • •

Available from your RCA Laboratory Measuring Equipment Distributor.

RCA H-F VoltOhmyst reads peak to peak for either simple or complex wave forms.


COMPLEX WAVE OR POSITIVE PULSE
CONVENTIONAL VTVM (READING POSITIVE PEAK ONLY) READS THIS VALUE
RCA H-F VOLTOHMYST (READING PEAK TO PEAK) READS THIS VALUE
AVERAGE
CONVENTIONAL VTVM READS THIS VALUE
AVERAGE
NEGATIVE PULSE
RCA H-F VOLTOHMYST READS THIS VALUE
CONVENTIONAL VTVM BECAUSE OF CAPACITANCE WHEN REVERSED, GIVES EITHER OF THESE EFFECTS

RADIO CORPORATION of AMERICA

TEST AND MEASURING EQUIPMENT **HARRISON, N. J.**

(*Continued from page 40A*)

pendability of full-wave selenium rectification and the lighter weight of selenium plates makes them easily portable. The units plug into normal 110-volt 50- to 70-cycle alternating current, and are extremely economical on current usage.

TRADE LITERATURE

Copper-oxide Rectifiers. Booklet. 28 pages. General Electric's complete line of copper-oxide rectifiers and controls for electroplating, anodizing, electrocleaning, electropolishing, and other electrolytic processes are shown in this booklet. It explains the advantages of unit installation of rectifiers over the old central power supply system and points out the advantages of the GE "package power." Technical diagrams and tables listing the complete range of packages for both manually and automatically controlled rectifiers and what they will do also are given. Available from the Appliance and Merchandise Department, General Electric Company, Bridgeport 2, Conn.

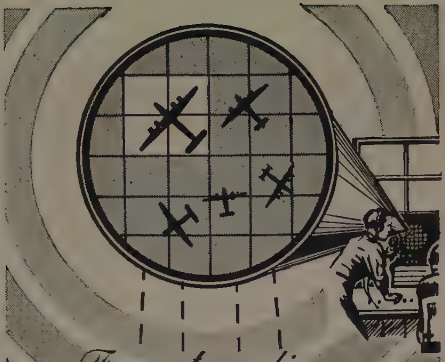
Asbestos Textiles. Booklet. 15 pages. A brochure issued by Johns-Manville containing photographs which show asbestos mining operations, carding and spinning machines, and the various Johns-Manville asbestos textile products, including reproductions of ten styles of asbestos cloth. A detailed description of asbestos roving, lap, yard, cloth, clothing, safety curtains, tubing, cord, wick, rope, tape, and oil burner wicking also is given. For copies of the brochure, write Johns-Manville, Box 290, New York 16, N. Y., and ask for form SP-7A.

Micro Tips. Micro Switch, of Freeport, Ill., has published the first issue of *Micro Tips*, a 4-page folder containing suggestions for uses of snap-action switches in industrial plants. A copy of *Micro Tips* is available by sending home address to "*Micro Tips*," care of Micro Switch, Freeport, Ill.

Molded Products. Folder. 4 pages. Published by Keystone Carbon Company, 1935 State Street, Saint Marys, Pa. "Keystone Precision Molded Products for the Electrical Industry," describes Keystone powder metal parts and "Selflube" bearings, Keystone slip ring and commutator brushes, and Keystone negative temperature coefficient resistance units.

Falk Backstop. Bulletin 10,080. 4 pages. Information on the construction and operating advantages of the Falk Backstop is contained in this bulletin. The Falk Backstop is said to provide a positive method for preventing a reverse rotation on conveyer drives, elevator head shafts, windlasses, winches, and on all applications where reverse rotation should not

(*Continued on page 46A*)



For extraordinary electrical performance

Use SILVER GRAPHALLOY*

GRAPHALLOY
TRADE MARK REG. U. S. PAT. OFF.

THE SUPREME CONTACT MATERIAL

in BRUSHES
for high current density ● minimum wear ● low contact drop ● low electrical noise ● self-lubrication

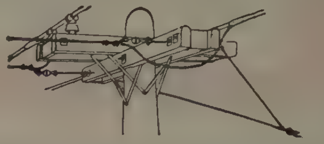
in CONTACTS
for low resistance ● non-welding character

GRAPHALLOY works where others won't! Specify GRAPHALLOY with confidence.

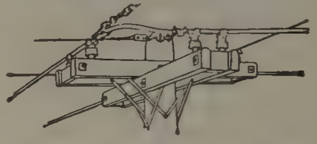
*A special silver-impregnated graphite

GRAPHITE METALLIZING CORPORATION
1053 NEPPERHAN AVENUE, YONKERS 3, NEW YORK

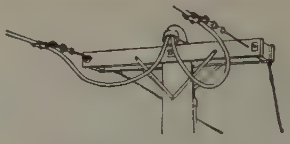
SAVE $5.00 A TURN OR DEADEND
on 000 to 1,500,000 C.M. cable with Matthews Cable Clamps



Shows how strain caused by right angle taps can be relieved



Outside Turns, Straight Guys



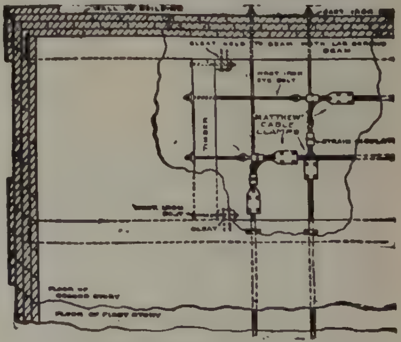
Deadending Two Cables

Order Number 2 for use on D.C. Cable or Number 3 for use on A.C. Cable.

Hundreds of thousands of these Clamps have been sold.

Every order for 000 to 1,500,000 C.M. Cable should include an order for Matthews Cable Clamps for every corner or deadend.

Write for Bulletin C.



Right Hand Turns in Heavy Cable

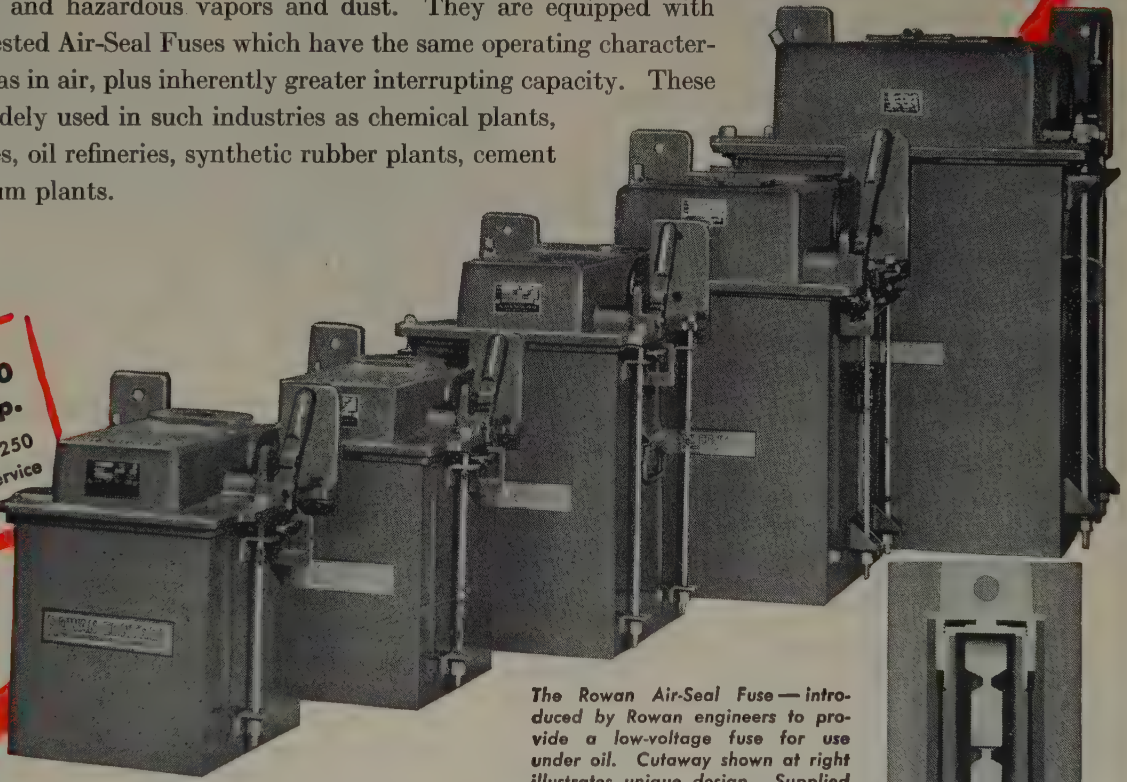
W. N. MATTHEWS CORPORATION
ST. LOUIS, U. S. A.

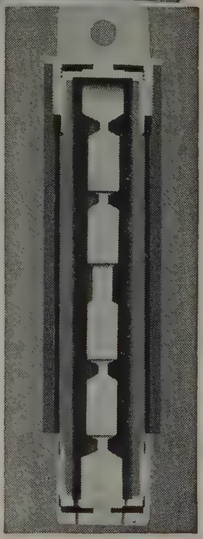
FOR MAXIMUM SAFETY AND CONTINUITY OF SERVICE

Rowan COMPLETELY OIL IMMERSED, FUSED, SAFETY LINE DISCONNECT SWITCHES

The Rowan Type 620 Safety Line Disconnect Switches are designed to provide dependable continuity of service in locations where the atmosphere is contaminated by corrosive elements, semi-hazardous and hazardous vapors and dust. They are equipped with Rowan Time-tested Air-Seal Fuses which have the same operating characteristics under oil as in air, plus inherently greater interrupting capacity. These switches are widely used in such industries as chemical plants, powder factories, oil refineries, synthetic rubber plants, cement mills and gypsum plants.

30 — 60 — 100
200—400 amp.
Available for 250
and 600 Volt Service





The Rowan Air-Seal Fuse — introduced by Rowan engineers to provide a low-voltage fuse for use under oil. Cutaway shown at right illustrates unique design. Supplied in 30—60—100—200—400 amp., 250 and 600 Volt.

Standard Features of the Type 620 Disconnect Switch:

1. Completely oil immersed. *2.* Equipped with Rowan Time-tested Air-Seal fuses. *3.* Disconnect switch of the quick acting contractor type with renewable contacts. *4.* Provision for locking disconnect switch in the "Off" position. *5.* Safety enclosing case mechanically interlocked to prevent lowering of tank when switch is in operating position or closing of switch when tank is lowered. *6.* Enclosing case is weather-resisting and dust-tight. *7.* Tank handles for ease of handling.

ROWAN CONTROL
THE ROWAN CONTROLLER CO., BALTIMORE, MD.

KEEP POSTED ON ELECTRON TUBES

Use this convenient coupon for obtaining the RCA tube reference data you need.

RCA, Commercial Engineering,
Section EW43, Harrison, N. J.

Send me the RCA publications checked below. I am enclosing $........ to cover cost of the books for which there is a charge.

Name______________________________

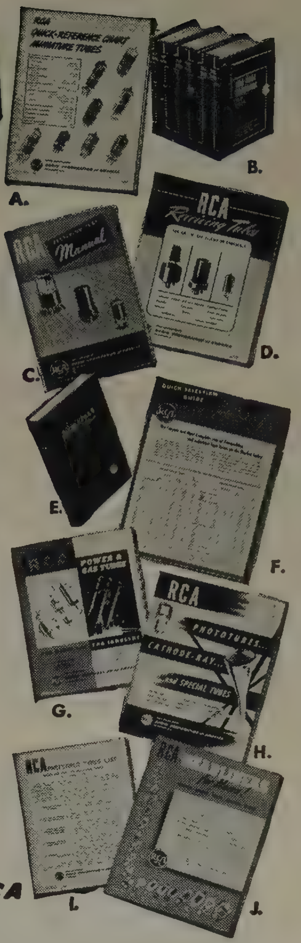
Address____________________________

City____________Zone______State_________

- ☐ Quick-Reference Chart, Miniature Tubes (*Free*). [A]
- ☐ HB-3 Tube Handbook (*$10.00*)*. [B]
- ☐ RC-15 Receiving Tube Manual (*35 cents*). [C]
- ☐ Receiving Tubes for AM, FM, and Television Broadcast (*10 cents*). [D]
- ☐ Radiotron Designers Handbook (*$1.25*). [E]
- ☐ Quick Selection Guide, Non-Receiving Types (*Free*). [F]
- ☐ Power and Gas Tubes for Radio and Industry (*10 cents*). [G]
- ☐ Phototubes, Cathode-Ray and Special Types (*10 cents*). [H]
- ☐ RCA Preferred Types List (*Free*). [I]
- ☐ Headliners for Hams (*Free*). [J]

**Price applies to U. S. and possessions only.*

TUBE DEPARTMENT
RADIO CORPORATION of AMERICA
HARRISON, N. J.



(*Continued from page 44A*)

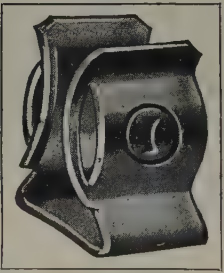
occur. Available from the Falk Corporation, 3001 West Canal Street, Milwaukee 8, Wis.

French Catalogue. A new general catalogue entitled, "Specification Index for Bristol Instruments," just has been published in the French language by The Bristol Company, Waterbury 91, Conn. The catalogue, number W1815, contains 24 pages of information on the Bristol line of automatic controlling, recording, and indicating instruments for use in industry, and gives hints on how they can be used effectively to save time and money and promote efficient operation in manufacturing processes. Specification data are given on each instrument listed.

Simplex Wires and Cables. A general catalogue containing little or no technical information which is designed to be an over-all bird's-eye view of the company and its products, without any attempt to give specific and concrete information has been issued by Simplex Wire and Cable Company. A quick nontechnical description of some of the more popular Simplex wire and cables has been given. Available from the Simplex Wire and Cable Company, 79 Sidney Street, Cambridge 39, Mass.

ILSCO
LUGS AND CONNECTORS

ILSCO FUSE CLIPS
BELONG IN YOUR PRODUCTS



- special alloy material
- secure mountings
- rounded corners
- perfect fit for fuse
- 12% cooler by test
- attractive prices

ORDER TODAY . . . IMMEDIATE SHIPMENT
Write for 54-page illustrated catalog

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AERODYNAMICISTS • THERMODYNAMICISTS
STRESS ANALYSTS • AIRCRAFT DESIGNERS

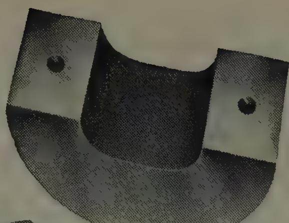
North American Aviation has a number of excellent openings for engineers qualified in the fields listed. Salaries commensurate with training and experience. Please include complete summary of training and experience in reply.

Engineering Personnel Office
NORTH AMERICAN AVIATION, INC.
Municipal Airport, Los Angeles 45, California

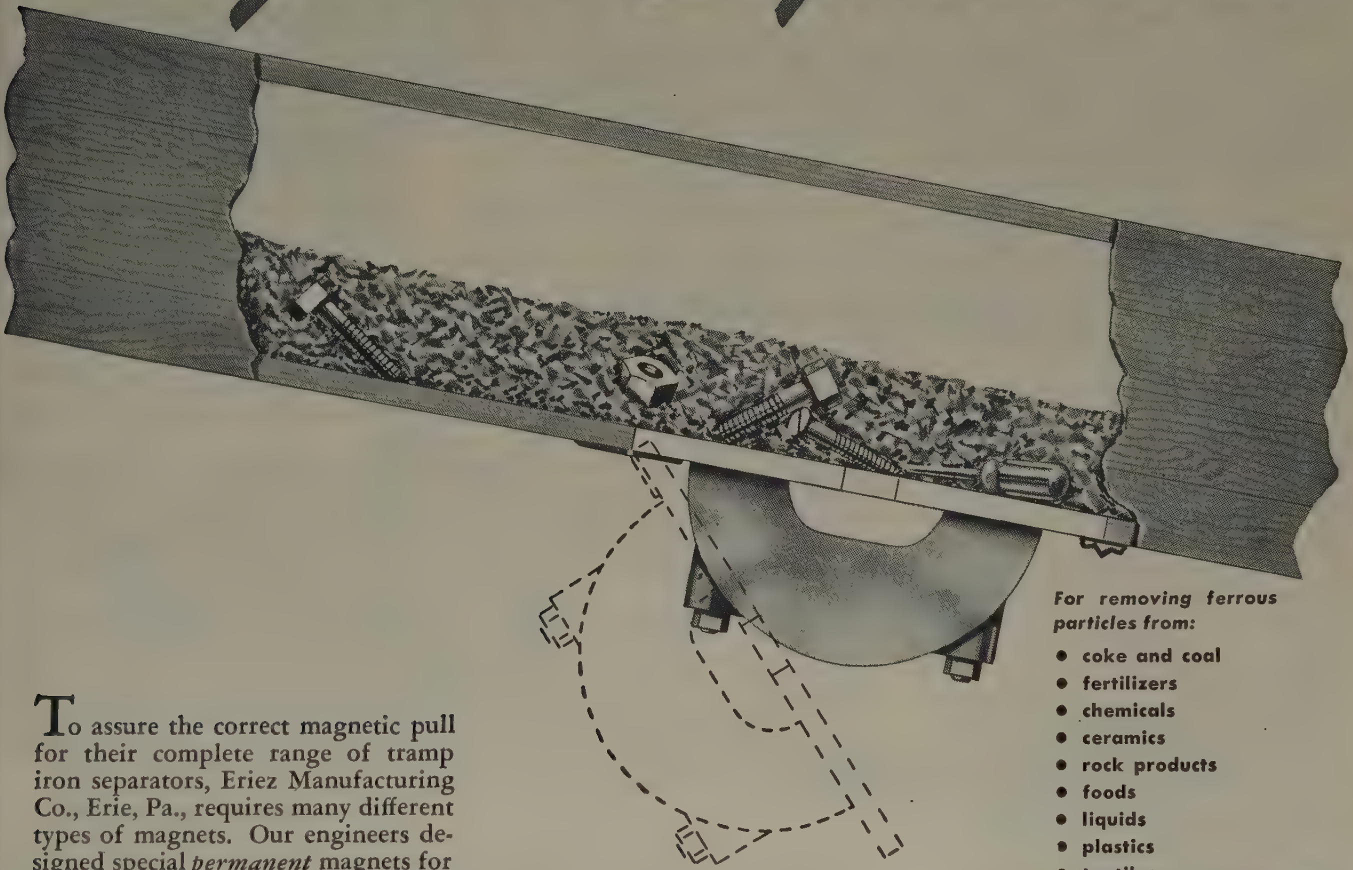
Electron Tube Publications

The AIEE conference on electron tubes for instrumentation and industrial use which was held in Philadelphia, Pa., March 29–30, 1948, evoked great interest in vacuum tube improvement. The full text of the papers presented, including discussions that took place, are included in the "*Proceedings of the Conference on Electron Tubes.*" Also available is the "*Report on Electron Tube Survey of Instrument Manufacturers and Laboratories,*" prepared by the AIEE joint subcommittee on electronic instruments and based on a survey of approximately 900 electron tube using organizations made early in 1947 to ascertain the need for improved electron tubes. It includes the background of the survey, a copy of the questionnaire, and the results which have been derived from the survey.

If purchased singly, the price of the "*Proceedings*" is $3 ($1.50 to AIEE members); while the price of the "*Report on Electron Tube Survey*" is $2 ($1 to AIEE members). However, if both publications are ordered, the total cost of the two is only $4 ($2 to AIEE members). These publications are obtainable from the AIEE ORDER DEPARTMENT, 33 WEST 39th STREET, NEW YORK 18, N. Y.



Permanent Magnets do it Better in *Magnetic Separators*



For removing ferrous particles from:

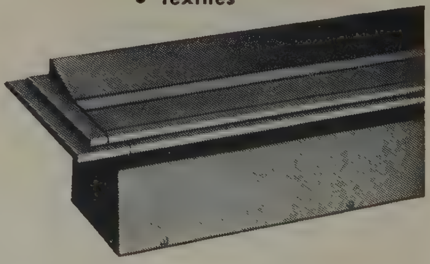
- coke and coal
- fertilizers
- chemicals
- ceramics
- rock products
- foods
- liquids
- plastics
- textiles

To assure the correct magnetic pull for their complete range of tramp iron separators, Eriez Manufacturing Co., Erie, Pa., requires many different types of magnets. Our engineers designed special *permanent* magnets for the entire Eriez line, bringing *high efficiency* and *low cost* to the removal of ferrous particles from such diverse materials as air, liquids, coal, and rock products. Materials and processing equipment *in many industries* are now protected by Eriez job-fitted separators using *Indiana Steel* permanent magnets.

Only permanent magnets offer these advantages:

1. Steady, everlasting strength.
2. No wiring or electrical current needed.
3. Minimum installation cost.
4. No operating cost.
5. Cool running—no temperature effects.
6. Not affected by moisture.
7. Easily installed in original equipment.
8. Uninterrupted operation.

Perhaps *you* have a job that permanent magnets can do better. Our forty years' experience in permanent magnets and our exceptional design service are at your call. A discussion with our engineers may develop unexpected savings and increased efficiency in your product. Write for complete information.



Eriez "Giant" Magnetic Separator
The largest Alnico magnetic separator produced

THE INDIANA STEEL PRODUCTS COMPANY

PRODUCERS OF "PACKAGED ENERGY"
6 NORTH MICHIGAN AVENUE • CHICAGO 2, ILL.
SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

PLANTS {VALPARAISO, INDIANA
CHAUNCEY, N. Y.

CLASSIFIED ADVERTISING

For help and situations wanted, $0.60 per line for AIEE members, others $1.00. Sale and purchase of used machinery, etc., $1.50 per line, minimum 5 lines, maximum 30 lines, not available to dealers.

Positions Wanted

GRADUATE ELECTRICAL ENGINEER, age 40, experience electric, water & sewer utilities, state highway, railway signaling, U. S. Engineer office. Desires executive position, preferably southwest Connecticut or Washington State. Address: Box 591, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

REGISTERED ELECTRICAL ENGINEER, ten years experience in distribution, transmission, manufacturing; desires position involving equipment application, system planning, or operation. Member A.I.E.E. Prefer Missouri Valley, Far West, or New York area. Address: Box 612, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ENGINEER, age 40, single, BS in EE, MS in CE. Sixteen years in design and construction of transmission lines, steam-electric generating stations, substations, highways and small highway structures. Professional registration. Desires position with responsibilities commensurate with above experience. Salary $9000. Address: Box 613, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

INDUSTRIAL-ELECTRICAL ENGINEER, M.S. in I.E., B.S. in E.E., age 33, broad experience in design, development, production and application of electromechanical products. Desires position combining production engineering with sales or service engineering, possibly as assistant to general manager or equal. Address: Box 614, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

B.S.E.E. June 1948 graduate, age 27, veteran, married, interested in legal, costs, production and sales problems, desires to train for managerial position with small or moderately sized concern. Address: Box 615, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

AVAILABLE on reasonable notice: ELECTRICAL ENGINEER—Registered in Pa., technical school graduate in E.E., 7 yrs. field experience in electrical construction; 21 yrs. association with electrical contracting and consulting engineering firms in construction and design of electrical power, lighting and associated distribution systems. At present employed by consulting engineers, but desire to make connection with organization where benefits will be mutual. Age 44. Married. Position desired in Philadelphia, Pa., or vicinity. Address reply to P. O. Box 4273, Phila. 44, Pa.

Positions Open

ENGINEERS. Technical Graduates, under 35. Opportunity for permanent position with nationwide fire insurance engineering organization. After training, work includes traveling for loss prevention inspections and consultations among leading industrial plants. Address: Box 608, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

RELAY OR PROTECTION ENGINEER—Connecticut Utility has opening for Graduate Electrical Engineer with experience in relay design and/or application of relays. To supervise the specification, application testing and maintenance of system protection. Age limt 45 years. Write giving age, education, technical experience, and salary expected. Address: Box 610, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ENGINEERING SCHOOL in Southeast has openings for a Professor of Electrical Engineering to teach graduate and undergraduate power subjects, an Assistant Professor in Communications work and several Graduate Assistants for the Fall of 1948. Graduate Assistants may obtain the Master's Degree in one year. Address: Box 616, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

PLANT ENGINEER—Mechanical or Electrical engineer with some experience in plant layout and design of production machinery. Man with at least 5 years experience needed. Good opportunity for advancement. Location, small town, upstate New York. Salary, dependent on qualifications. Address: Box 617, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ENGINEER WANTED—Mechanical or Electrical engineer graduate with plant experience needed to work as assistant to Chief Engineer of medium sized manufacturing plant. Plant now modernizing its manufacturing processes. Good opportunity for man willing to work. Give complete record of education and experience and salary desired. Location, Western New York. Address: Box 618, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ELECTRICAL ENGINEER: Graduate, 30–45, experienced in the design, testing and application of fractional h.p. and small integral h.p. motors. Desire man with thorough technical education and good background of design and testing experience for responsible position with well established company, 700 employees. Salary commensurate with experience and ability. Send complete record, which will be held strictly confidential. Location New Jersey. Address: Box 619, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

CHIEF ENGINEER with heavy experience in small electrical assemblies. Forty to fifty years of age, capable of supervising a staff of about fifty men. Wanted by a long established, nationally known, New England manufacturer. Address: Box 620, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ENGINEERS, Bachelors—Large College offers $3000–$3300 approx. half time teaching—studying. Masters to $6000. Send phone, photo, qualifications. CLINE TEACHERS' AGENCY, East Lansing, Michigan.

WANTED—YOUNG ENGINEER FOR ELECTRIC SYSTEM DISPATCHING—Large Northern New England Utility has opening for a young man with electrical engineering training who is interested in Power System Dispatching and Operating. Experience in hydro and steam generation preferred. Early interview will be arranged for qualified applicant. Address: Public Service Company of New Hampshire, 1087 Elm Street, Manchester, New Hampshire.

WANTED ELECTRICAL ENGINEER with one to four years experience with motors, generators, switchgear or similar apparatus, who likes combination engineering and business for position in Headquarters Sales Department. Address Desk 143, Electric Machinery Mfg. Company, Minneapolis 13, Minnesota.

ELECTRICAL ENGINEERING TEACHER: Duties: Teaching, laboratory layout and equipment selection. Industrial experience desired. At least one year of graduate study required. Rank and salary open. Engineering Dept., San Jose State College, San Jose, California.

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Societies **Personnel Service, Inc.**

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In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of these advertisements, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, non-profit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns.

Apply by letter addressed to the key number and mail to the New York Office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription rate of $3.50 per quarter or $12 per annum, payable in advance.

Men Available

RECENT GRAD, B.S.E.E.; age 25; ex Navy Communications Officer; excellent conversationalist; sales personality. Desires sales engg opening with challenging future. E-354.

ENGR; age 43; intimate knowl petroleum indus constr, des, procurement, foreign oprns, economics, languages, seeks west coast or foreign pos expanding firm requiring energetic exec to assume major responsibilities. E-355.

PHYSICIST, B.S. plus grad study; 26, married; 1 yr general engg, 4 yrs radar maintenance and some geophysical exper. Desires foreign pos requiring science or electronic background. Some business training. E-356.

ELEC ENGR; 23, married; one and one half yrs exper as G. E. Test Engr. Desires pos located in the Far West. E-357-483-C-5-San Francisco.

JR ELEC ENGR, B.E.E., 1948; 22, single; Navy Air Corps vet. Majored in pwr engg. Desires pos in Conn or New York and vicinity in pwr field or aircraft elec systems. E-358.

EXEC ENGR, B.S.E.; age 35; 14 yrs diversified admin, supervisory exper in engg and purchasing on large proj including pressure vessel work; outstanding record; adaptable, cooperative, responsible; excellent personality and appearance. Desires New York location. E-359.

Positions Available

ELECTRICAL ENGINEERS, 27–35, with two to five years general technical experience in the utility field for systems operation and general field work. Knowledge of Portuguese or Spanish desirable but not necessary. Salary, $6000–$8000 a year. Location, South America. Y-200.

ELECTRIC UTILITY ENGINEER with minimum of three to five years experience in both office and field work on electric utility operations. Some knowledge of Spanish or Portuguese desirable. Salary, $6000–$7200 a year. Location, New York, N. Y. Y-201.

ENGINEERS. (a) Electrical Engineer, graduate, 28–35, for large electrical wire and cable manufacturer on calculation, specifications and recommendation work on paper and varnished cambric power cable. Several years experience with utility on underground transmission feeders desirable. Apply by letter giving experience record and personal data. (b) Electrical Engineer, graduate, 28–35, for sales engineering work with large electrical wire and cable manufacturer with ultimate emphasis on sales. Training period of two or three years as engineering assistant in sales engineering department on application work. Previous experience on underground distribution and transmission desirable. Apply by letter giving experience record and personal data. Location, New York, N. Y. Y-274.

ELECTRICAL AND/OR MECHANICAL ENGINEER, 30–35, with thorough technical education, to prepare plans and specifications for installations, in industrial and commercial buildings, of heating and ventilating, plumbing and other piping trades, electric light and power wiring, air conditioning; prepare estimates of cost of such installations; supervise such work being performed by sub-contractors. Should have a general acquaintance with all of the subjects mentioned above and expert knowledge of one or more. Should have administrative ability to employ and direct assistants or specialists. Salary, to $6000 a year, plus bonus. Location, Ohio. Y-291.

TRANSFORMER ENGINEER to take charge of design and production of small and medium transformers. Must have at least five years experience in this type of work. Salary, to $6000 a year. Location, northern New Jersey. Y-541.

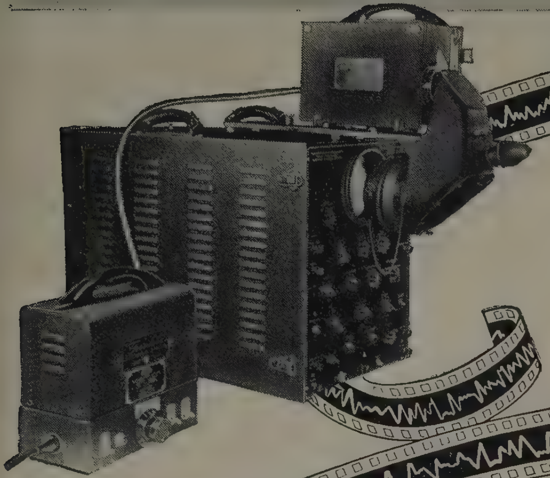
ENGINEERS, experienced, mechanical, electrical, or civil degrees, under 35, for major oil company, in their operating, terminal and engineering departments. Duties will consist of construction of new tanks, layout of industrial plants, service stations, etc. Salary, $5000–$6000 plus field allowance, retirement plan and advancement opportunities. Location, Orient. Y-546.

ENGINEERS OR PHYSICISTS in research design or development, preferably in the field of high precision electro-mechanical equipment incorporating servomechanisms and controls, analogue computers, digital computers, gyroscopic instruments, small motors, synchros, resolvers, etc., for military and commercial applications. Salary, $8500 a year, depending on qualifications. Location, New York Metropolitan Area. Y-588.

INSTRUCTORS in electrical engineering for undergraduate courses in electric power, electronics and communications. Advanced degrees and teaching or professional experience desired. Rank dependent upon qualifications. Location, New England. Y-590.

(Continued on page 50A)

100 feet of film is a lot of film to handle . . .
yet it's done conveniently with
DU MONT OSCILLOGRAPH-RECORD EQUIPMENT



Film rolled on spools is easily inserted and removed when making oscillograms with Type 314 Oscillograph-record Camera. Up to 100 feet of 35-mm. film is readily accommodated by this camera designed for both single-frame and continuous-motion recording of oscillograph patterns.

CAT. NO. 1217-E (f/2.8 coated lens) .... **$ 980.00**
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And after exposing the film, the Type 2512 Motor-driven Processing Unit is available for developing the entire 100-foot roll with minimum of bother and without danger of scratching the emulsion. Merely insert film in processing unit and start the motor. Provision is made in this unit for adding and pouring off processing solutions.

CAT. NO. 1372 (115 volts 50-60 cps) **$231.00**

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(Continued from page 48A)

DISTRIBUTION ENGINEER, electrical, to take entire charge of distribution work for public utility in the supervision of extensions and new work. Salary open. Location, Venezuela. Y-635.

ENGINEER, electrical degree, and some practical experience with aircraft systems, for maintenance engineering division of a company in Texas. Y-645S.

HYDROELECTRIC ENGINEER, for engineering department, to teach hydroelectric engineering and to explore the possibility of introducing hydroelectric schemes in Burma. Will also make broad surveys and render assistance which may prove invaluable to the government and people. Y-660.

ASSOCIATE AND ASSISTANT PROFESSORS AND INSTRUCTORS not over 40, in electrical engineering. Must have experience with electrical machinery including control devices, servo mechanisms, etc. Salary, $3000–$4800 for nine months. Location, New England. Y-666.

PLANT ENGINEER, electrical or mechanical graduate, with ten to fifteen years experience in the field of plant engineering and/or plant maintenance. Will be responsible for a preventive maintenance program for a modern and highly mechanized veneer and ply wood mill. Salary, to $6600 a year, depending upon qualifications. Location, Kentucky. Y-688.

ASSISTANT ELECTRICAL SUPERVISOR, 25–35, electrical graduate, familiar with industrial application of electronic devices is desirable. Prefer man with industrial plant experience in installation and operations. General Electric or Westinghouse post-graduate training is desirable. Duties will include all types of work associated with the use of power in manufacturing operations of a paper mill. Position permanent. Salary open. Location, New England. Y-693.

DESIGN ENGINEERS with degrees in civil, mechanical or electrical engineering, and five to ten years experience in design and engineering work with a recognized industrial firm. Salary commensurate with experience. Location, Tennessee. Y-706.

ASSISTANT PROFESSOR of electrical engineering, M.S. preferred, although not necessary. Industrial and teaching experience desirable. Teaching experience may be waived where industrial experience is outstanding. Salary, $3500–$4500 for eleven months. Location, Ohio. R-4824(e)-C.

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HIGHLIGHTS........

Summer Meeting. Final arrangements for the summer general meeting are complete. A few last minute instructions appear in this issue (*page 601*). It has come to our attention that a number of members have been having trouble getting their tourist cards for the Mexican trip from certain consulates. This happened because applications for the cards were made at "honorary" consulates which do not have authority to issue tourist cards. A revised list of authorized consulates appears in this issue (*pages 601–02*).

Digests. Continuing the presentation of the new type of digest which replaced the abstract (*EE, Apr '48, p 378*), several summer general meeting digests and additional North Eastern District meeting digests appear in this issue (*pages 516, 531, 532, 538, 550, 562, 563, 564, 569, 570, 579, 580*).

Great Lakes Papers. Brief author's digests of conference papers presented at the AIEE Great Lakes District meeting, Des Moines, Iowa, April 1–3, 1948, are presented in this issue (*pages 587–8*). Similar digests of the conference papers presented at the North Eastern District meeting which was held in New Haven, Conn., April 28–30, 1948 are scheduled for publication in the July issue.

Electron Tube Papers. The conference on electron tubes for instrumentation and industrial use which was held in Philadelphia, Pa., March 29–30, 1948, was the first of the new type of AIEE national meetings known as AIEE conferences. Last month a news report on the electron tube conference was published (*EE, May '48, pp 494–97*). This month short authors digests of the papers presented at this gathering are presented (*pages 589–600*). The full texts of the papers and discussions soon will be available in pamphlet form as the "Proceedings of the Conference on Electron Tubes" from the AIEE Order Department.

Rubber Conference. A news report on the conference on electrical engineering problems in the rubber and plastics industries, second of the new AIEE conferences, appears in this issue (*pages 603–05*). Brief authors' digests similar to those of the electron tube conference are schedule for publication in next month's *ELECTRICAL ENGINEERING*. As is the case with the conference on electron tubes, full texts of these papers and their discussion also will be made available in pamphlet form in the near future.

New Haven Meeting. An interesting program of some 71 technical topics including 18 technical program papers, 32 District papers, and 21 Student papers was held at the AIEE North Eastern District Meeting in New Haven, Conn. (*pages 605–07*). A report on the District Student conference and the District executive committee meeting also appears in this issue (*pages 607–09*).

Pacific Meeting. A variety of papers on engineering problems and developments in the Pacific North West will be presented at the AIEE Pacific general meeting. This year the meeting will take place in Spokane, Wash., August 24–27, 1948 (*page 602*).

More AIEE Conferences. The success of the first two AIEE conferences has aroused the interest of several AIEE technical committees. So far, nine new conferences have been planned with dates running well into 1949. Such subjects as textile industry problems, nucleonic instrumentation, electronic aids to medicine, and materials handling as well as repeats on the electron tube and the rubber conferences are among those planned (*pages 602–03*).

Magnetostriction Generators. The use of magnetostriction effects for the conversion of mechanical to electric energy, or the converse, is the subject of this article, latest in a series being presented as a review of electric power sources (*pages 571–8*).

Circulation. AIEE membership and subscribers to *ELECTRICAL ENGINEERING* will be interested to learn that for the last three issues, April, May, and June, our circulation has been at the highest point in Institute history: 45,000 copies.

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Isotope Separation. There are eight methods for separating isotopes, but it is necessary for any given separation problem to select the most suitable method with consideration for the amounts and concentration wanted, as well as the particular elements whose separation is desired. That the question is no longer a scientific one but an economic and industrial one is the conclusion drawn in the seventh article of a series being developed by the nucleonics committee (*pages 581–6*).

Turbine-Generator Standards. After three years of trial use of AIEE Standards 601 and 602 covering large 3,600-rpm turbine generators, the progress made by the manufacturers and their acceptance of the program are reviewed (*pages 548–9*).

Mexican Telegraph Development. The inadequacy of Mexico's telephone and telegraph facilities was indicated by a recent survey which showed that equipment was old, in poor condition, and insufficient. However, present plans for the improvement of these communication systems promise a modern and efficient service (*pages 513–15*).

Mexican Steel Industry. Steel consumption in Mexico has increased 120 per cent in the last six years, accompanied by a comparative growth of steel production. Both iron ore and coking coal deposits are abundant. New plants are increasing the country's refining and processing capacity *pages 533–4*).

Tube Design Survey. The scope and uses of electron tubes—from peanuts to converters—continuously is changing and developing. Recent achievements and present trends in electron tube design are presented (*pages 517–30*).

Automatic Pilots. The analysis and description of the operation and design of automatic pilots indicates that complete flight path control can be accomplished. The application of servomechanisms to airplane control has been an evolution from simple short-time relief toward complete control (*pages 551–61*).

Microwave Attenuation Standard. In line with the program of the National Bureau of Standards for extending the standards of electrical quantities up through microwaves, a standard of attenuation has been established. An intermediate-frequency substitution method using a waveguide-below-cutoff standard attenuator has been tested and adopted (*pages 535–7*).

Repulsion Motor Analysis. An equivalent circuit for the repulsion motor has been developed along similar lines to those used for other types of equivalent circuits. Performance calculations and motor design should be aided by this new method of analysis (*pages 565–8*).

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices, 500 Fifth Avenue, New York 18, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress o fMarch 3 ,1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925.
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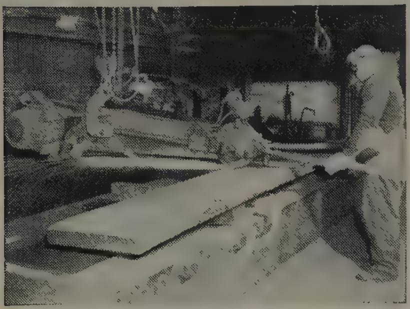

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Here's an example. Manually operated swing grinders are used in the South Works of the Carnegie-Illinois Steel Corporation, Chicago, to remove surface defects from alloy steel slabs prior to rolling. Class "B" motors that were used to drive them failed frequently because of overloads. When overload relays were installed to protect the motors, production decreased because overheated motors cut out every 15 to 20 minutes forcing the operators to wait for the motors to cool.

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INDUSTRIAL NOTES ....

Raytheon Elections. The directors of Raytheon Manufacturing Company, Waltham, Mass., elected Laurence K. Marshall, chairman of the board and Charles Francis Adams, Jr., president.

Turner Construction Report. In an annual report to stockholders, Turner Construction Company, N. Y. reported a year's volume of $45,845,092 for 1947 as compared with $28,871,468 the previous year. The company has started the year 1948 with an estimated volume of $52,733,000 of which $45,650,000 is expected to be completed this year. At the annual meeting, Mrs. Elsie S. Marr was elected assistant secretary. This is the first time a woman has been an officer of the company.

Organization Changes. Thomas B. Hasler, formerly president of Wilson Welder and Metals Company, Inc., N. Y., a wholly owned subsidiary of the Air Reduction Company, Inc., was elected chairman of the board of directors succeeding C. E. Adams who resigned as chairman and director; and F. B. Adams, Jr., was elected president and a director.

Philco Appointment. Thomas A. Kennally, who has been vice-president in charge of sales, has been appointed vice-president and assistant to the president of Philco Corporation, Philadelphia, Pa., to assist in the over-all direction of the corporation's activities.

New Officers. P. van den Berg, who was formerly vice-president and general manager, has been appointed president of North American Phillips Company, Inc., N. Y. Other officers of the corporation are: L. J. Chatten, vice-president and general commercial manager; A. Worsnop, treasurer; T. R. Naughton, secretary; and L. J. A. van Lieshout, who has been appointed assistant vice-president. A. Vernes has been appointed president of Phillips Export Corporation, succeeding Mr. van den Berg who now becomes chairman of the board. H. G. Noordberg is newly appointed as a vice-president, and F. T. Page as treasurer. The other officers are: M. M. N. J. Dorenbosch, vice-president, and T. R. Naughton, secretary.

Luminous Industries Inc. Luminous Industries Inc., have been formed to manufacture and distribute luminous compounds and related products with Erwin Schapira as president and treasurer. The new corporation, which will maintain offices, laboratory, and manufacturing facilities at 43 West 16th Street, New York, N. Y., also announced the other principals as Doctor Paul A. Tumarkin, who will serve as vice-president and director of research and Boris Z. Gorlin as vice-president and director of engineering and manufacturing.

Arnott Named. Edward G. F. Arnott has been named assistant director of research for the Westinghouse Lamp Division.

Name Change. Stockholders of the Mathieson Alkali Works, Saltville, Va., at the annual meeting approved a change in the company's name to Mathieson Chemical Corporation; authorized the issue of 500,000 additional shares of common stock; approved the retirement of all but the present outstanding shares of preferred stock; and elected directors for the fiscal year. Directors elected to serve for the fiscal year were Howard Berry, L. G. Bissell, H. Donald Campbell, Malcolm G. Chace, John P. Chase, George W. Dolan, A. U. Fox, Sinclair Richardson, and Robert G. Stone.

General Sales Manager. Joseph H. Humble of the Kester Solder Company, Chicago, Ill., has been appointed general sales and advertising manager.

B & W President. Peter D. White has been elected president of the Babcock and Wilcox Tube Company. Luke E. Sawyer was elected vice-president and general manager and E. A. Livingstone was elected vice-president in charge of sales.

Allis-Chalmers Appointment. E. H. Horstman and Hans P. Dahlstrand have been named respectively chief engineer and director of engineering of the Allis-Chalmers steam turbine department.

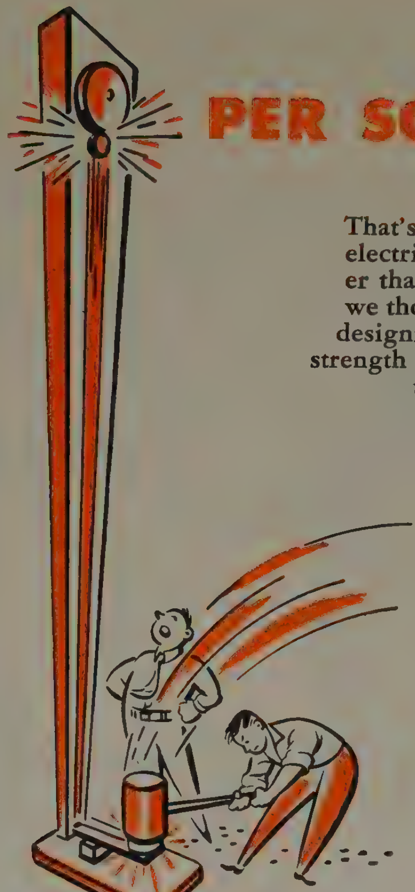
Stromberg Income. Net income of the Stromberg-Carlson Company, Rochester, N. Y., for the year ended December 31, 1947, was $1,084,149, after taxes, depreciation, and so forth, equal to $3.50 a share on the common stock. This compares with net income of $802,910, or $2.57 a share, in 1946 and $2.51 a share in 1945. The 1947 earnings before taxes were $1,759,149, necessitating provision of $675,000 for United States and Canadian taxes.

Purchase. The lamp department of the General Electric Company, Nela Park, Cleveland, Ohio, has purchased the former American Magnesium Corporation plant at 1099 Ivanhoe Road, Cleveland. The property, consisting of six acres of land, a 53,000 square foot office building, both 1-story structures, will become headquarters of the lamp department's chemical products division, now located at Nela Park.

Radio Set Plant. A new radio set manufacturing plant at Clyde, N. Y., 40 miles west of Syracuse, was placed in operation by General Electric's receiver division

(*Continued on page 44A*)

50,000 LBS. PER SQ. IN.*



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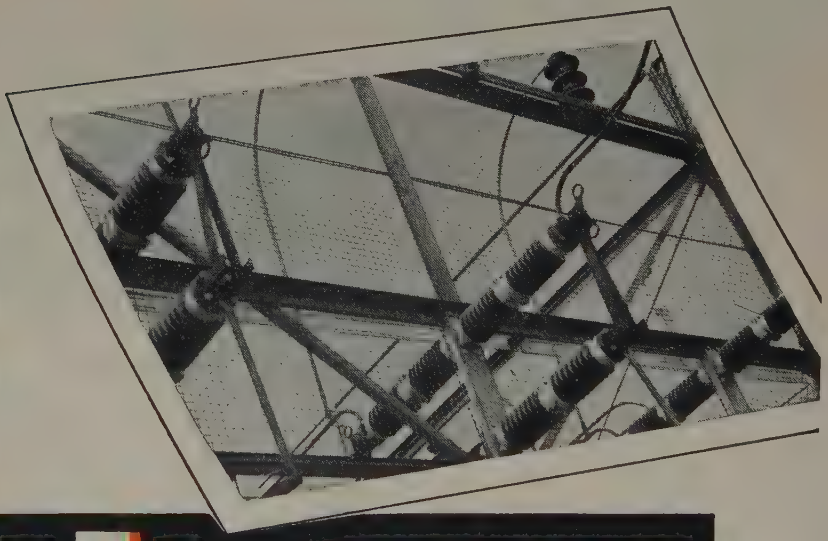

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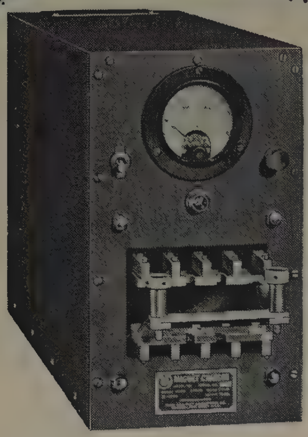

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RADIO FREQUENCY
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(*Continued from page 14A*)

March 15. Known as the Clyde Receiver Works and managed by Martin Hildenberger, the plant will make table model radios.

Vice-President. At the last meeting of the board of directors of Acme Electric Corporation of Cuba, N. Y., William E. Wilson, who has been sales manager of the company for the past three years, was elected vice-president in charge of sales.

Appointment. Doctor J. V. Pennington, consulting engineer and petroleum technologist, has accepted appointment as associate director of Southwest Research Institute of San Antonio and Houston, Tex.

Assistant General Manager. Joseph R. Lex has been appointed assistant general manager of Progressive Welder Company, Detroit, Mich.

Bohuslav Joins Engineering Controls, Inc. Hans Bohuslav has joined Engineering Controls, Inc., Los Angeles and New York, as vice-president in charge of engineering.

New Corporation. Formation of the Tri-Line Corporation, with main offices at 170 Franklin Street, Buffalo 2, N. Y., and with branch offices at 135 Spring Street, Rochester 8, N. Y., and 357 Coolidge Avenue, Syracuse, N. Y., has been announced by C. C. Tiedman president of the new corporation and formerly a partner of Industrial Equipment Company, Buffalo. Tri-Line Corporation takes over the distribution and field engineering on resistance welding equipment produced by Progressive Welder Company, 3050 E. Outer Drive, Detroit 12, Mich., and the air and hydraulic equipment formerly handled by Industrial Equipment Company. G. H. Schliecker, who was also a partner of Industrial Equipment Company, is vice-president of the new corporation. L. H. Schliecker is in charge of the Syracuse office and L. H. Henry is in charge of the Rochester office.

George Koch Dies. George Koch, secretary, director, and sales manager of the Simpson Electric Company, Chicago, Ill., died February 15.

TRADE LITERATURE

Instrument Recording Material. Catalogue. 4 pages. Describes Kodak Linagraph films and papers for use in instrument recording. Issued by the Industrial Photographic Division, Eastman Kodak Company, Rochester 4, N. Y.

Lign-o-matic Turret. Bulletin 483. 12 pages. Explanation of the patented design features, operating instructions, specifications and prices of the Lign-o-matic turret. Available without charge on request to Department 15D, Howe and Fant, Inc., 521 Flaxhill Road, South Norwalk, Conn.

Mallory Catalogue. Number I. Covers the Mallory line of capacitors, contacts,

(*Continued on page 54A*)

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TRUMBULL

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(*Continued from page 44A*)

rectifiers, resistors, switches, vibrators, welding tips and holders, the various special metals and alloys for which Mallory is known, as well as its line of special metallurgical products. P. R. Mallory and Company, Inc., 3029 East Washington Street, Indianapolis 6, Ind.

Morse Morflex Catalogue. C 41–48. 32 pages. The catalogue devoted to the Morse Morflex flexible coupling line. Covered in the publication are such points as the development of couplings, their construction and working principle. Available through distributors of Morse mechanical power transmission products, Morflex couplings are made in a variety of capacities ranging from the "Junior" morflex with 0.06 horsepower rating per 100 rpm, to double morflex couplings with a 13.80 horsepower rating per rpm. Morse Chain Company, 7601 Central Avenue, Detroit 8, Mich.

Selecting Relays. A relay guide issue by Allied Control Company, Inc., 2 East End Avenue, New York 21, N. Y., illustrates a line of small, compact, space saving relays of varied types and features. A table enumerates the specifications of each relay. These specifications show maximum contact arrangement; contact rating current, d-c and a-c; coil operation, a-c and d-c; coil data in volt amperes a-c or watts d-c, giving maximum, rated and minimum specifications; maximum d-c ohms of standard coils; maximum rated volts of standard coils; dimensions, including length, width, and height; weight in ounces.

Wheelco Bulletin. A 12-page bulletin containing illustrations, wiring diagrams, and a description of Wheelco flame-otrol combustion safeguard systems has been released. Listings of instrument models with recommendations for application, sensing units for gas and oil operation and explanation of the new "blue sensitive cell" and "safe start relay" are given. Bulletin Fl-1 from Wheelco Instruments Company, 847 West Harrison Street, Chicago 7, Ill.

Branding Iron Catalog. Number 300. A catalogue covering electric branding irons. Included therein are several new types of branding irons with instructions for ordering, also a list of materials which may be branded; instructions for using electric branding irons; how to determine branding speeds and suggestions for designing a brand which will be effective and at the same time economical to produce. This catalogue also shows full illustrations of stock branding irons with blank dies. Available from the Hexacon Electric Company, 174 West Clay Avenue, Roselle Park, N. J.

Molded Magnetic Parts. Bulletin 40A. 24 pages. "Trancors by Lenkurt" describes the complete line of molded magnetic cores, core assemblies, coil assemblies, and filters manufactured by the company. These products, engineered to meet the technical requirements of Lenkurt Carrier telephone and telegraph gear, recently have been made available for application throughout industry. Lenkurt Electric Company, Inc., 1101 County Road, San Carlos, Calif.

"Power Points." The issue is devoted to the problem of electric power emergencies. It describes how standby protection, delivered by Onan emergency electric plants, provide security against losses caused by electric power failures. For copies of the booklet address Advertising Department, D. W. Onan and Sons Inc., Minneapolis, 5, Minn. Specify POWER POINTS, Emergency Power Issue, volume 4, number I.

Infrared Guide. Radiant heat processing for metal-working, plastics, textile, leather, graphic arts, paper, food, woodworking, building, glass and bottling, rubber and other industries are described in the booklet "Modern Baking, Drying, Heating with Industrial Infrared Lamps" issued by the Westinghouse Electric Corporation. Case histories are given to show how infrared cuts costs, speeds production, and saves space wherever heat is required for dehydrating, finish baking, or mass heating. A check list of applications for which it now is being used names more than 70 operations and processes in a wide variety of industrial plants. Copies of the booklet (A-3817) may be secured from Advertising and Sales, Westinghouse Lamp Division, Bloomfield, N. J.

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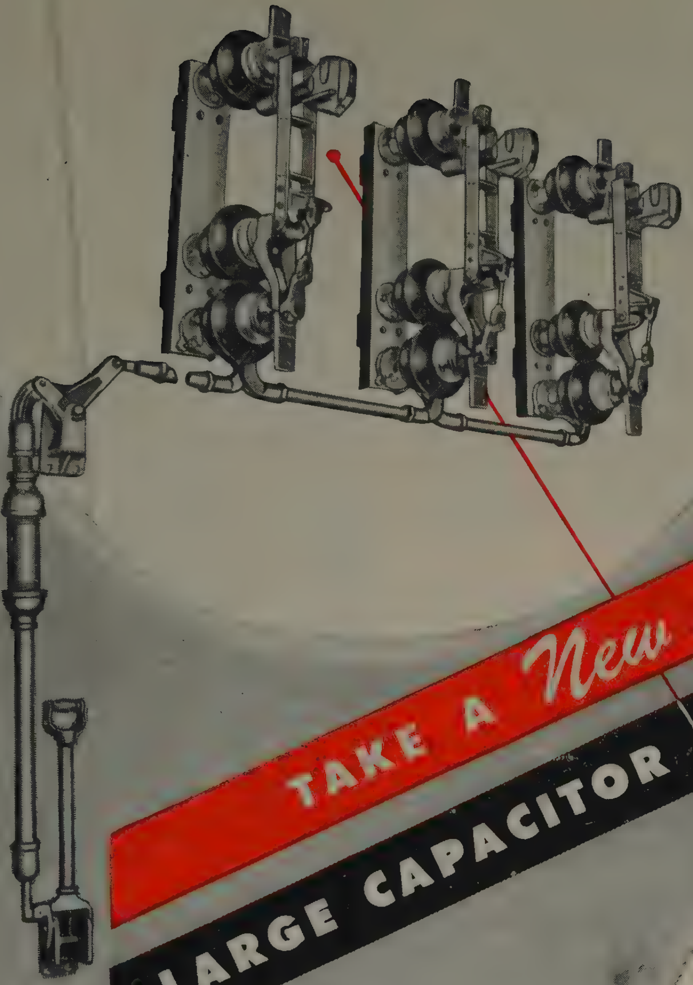

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M.S.E.E., many yrs. exper. as associate professor charge of electronics; author of many technical papers; 4 yrs. design in industries; desires teaching position. Address: Box 593, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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JUNE GRADUATE, ELECTRICAL ENGINEERING, 4 yrs. utility experience including 2 yrs. substation design, desires permanent work. Age 25, married, location immaterial. Address: Box 626, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

AVAILABLE July 1: Elec. Engineer graduate. At present co-ordinator of engineering college co-op. program; 7 years supervisory experience signal system construction; age 30. Desires administrative or sales position with electrical manufacturer. Prefers Northeast location. Address: Box 627, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

REGISTERED ENGINEER, B.E.E., 29, 5 years supervisory experience testing communication equipment, 2 years research and development in dielectrics, U.H.F. training. Capable administrator and writer. Desires responsible research, development or production position in electronics. Location Southern California or New York City. Address: Box 635, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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ENGINEERING SCHOOL in Southeast has openings for a Professor of Electrical Engineering to teach graduate and undergraduate power subjects, an Assistant Professor in Communications work and several Graduate Assistants for the Fall of 1948. Graduate Assistants may obtain the Master's Degree in one year. Address: Box 616, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ELECTRICAL ENGINEER: Graduate, 30–45, experienced in the design, testing and application of fractional h.p. and small integral h.p. motors. Desire man with thorough technical education and good background of design and testing experience for responsible position with well established company, 700 employees. Salary commensurate with experience and ability. Send complete record, which will be held strictly confidential. Location New Jersey. Address: Box 619, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

WANTED—YOUNG ENGINEER FOR ELECTRIC SYSTEM DISPATCHING—Large Northern New England Utility has opening for a young man with electrical engineering training who is interested in Power System Dispatching and Operating. Experience in hydro and steam generation preferred. Early interview will be arranged for qualified applicant. Address: Public Service Company of New Hampshire, 1087 Elm Street, Manchester, New Hampshire.

ELECTRICAL ENGINEER, experienced in design and construction of air cooled transformers to 200 KVA. Salary \$5000. Location, Southern Calif. Address: Box 628, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

POSITIONS AVAILABLE: Instructors, Assistant and Associate Professors in electric power, alternating current machinery, design, and transmission. M.S. degree preferred. Positions open about Oct. 1, 1948. Salary \$3,000 to \$5,200 dependent on experience. Location—Great Lakes region. Address: Box 629, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

ELECTRICAL ENGINEER with good theoretical background for independent research and development laboratory, Dayton, Ohio. Development for industrial client comprises small motors, industrial electric and electronic controls, apparatus and devices. In reply state education, age, experience and salary required. All replies held confidential. Address: Box 630, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

FACTORY SUPERINTENDENT. Electrical Engineer preferred. Not over 40. Experienced in supervising machine job shop production for electrical and mechanical apparatus. Knowledge of planning, methods, scheduling, costs, and ability to handle men required. Reports to Vice President and works closely with an efficient development department. Well established mid-west company offering good salary. Address: Box 631, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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ELECTRICAL ENGINEER to assist sales engineer in design and layout of street lighting, distribution and transmission systems for a nationally known manufacturer and supplier of electric pole line equipment. Some utility experience desirable. Location—New York City. Address: Box 633, ELECTRICAL ENGINEERING, 500 Fifth Avenue, New York 18, N. Y.

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WANTED: AIEE Transactions, vols. 1–5; 47 pts. 1, 2; 48 pt. 2; 52 pts. 2–4. Write Librarian, Montana State College, Bozeman, Montana.

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GRAD ELEC ENGR; 35, married; 6 yrs Naval radar and assoc eqpt, installation and maint; $2\frac{1}{2}$ yrs indus constr, estimating, purchasing. Will consider pos anywhere in No. America or England. E-361.

ELEC ENGR, BSEE plus grad math; 47, married; now mgr and chief engr electromech control company, 75 employees; 25 yrs exp util, mfg, devpmt. Desires perm pos N. Y. State or New England. E-362.

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GRAD ELEC ENGR; age 35; 13 yrs pub util, diversified exper, 8 yrs in pwr pooling. At present Load Control Supervisor desirous of respon pos with pub util or indus firm, preferably in some phase of pub contact work. E-364.

ELEC CONSTR EXEC; age 47; who has grown up in elec contracting indus in New York area, finds it necessary to move to a warmer climate because of bronchial asthma contracted in service while serving as elec engr for Air Transport Command. Has managed proj up to three and one half million dollars. Desirous of assoc with an elec contractor or engg firm or of representing an elec mfgr in Los Angeles area. E-365.

GRAD ELEC ENGR; age 27, veteran. Exper pwr system math, relay applications, load and fault current studies, switchgear requirements. Desires pos So. America. Previous work there. E-366.

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DESIGNER, electrical graduate, with at least five years' small transformer design experience, to design new and re-design radio and small transformers. Salary, \$6000–\$8000 a year. Location, Connecticut. Y-758.

(*Continued on page 64A*)

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(*Continued from page 62A*)

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POWER ENGINEER, 30–35, electrical graduate, with generating and transmission experience, to take charge of distribution. Spanish desirable. Salary, $6000–$7000 a year. Location, Cuba. Y-770.

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MAINTENANCE ENGINEER, preferably electrical graduate, thoroughly experienced on maintenance and construction of power equipment and distribution for mining project. Salary, $3600, plus room and board. Location, Central America. Y-816.

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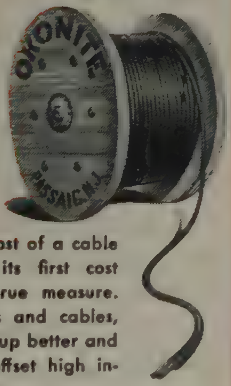

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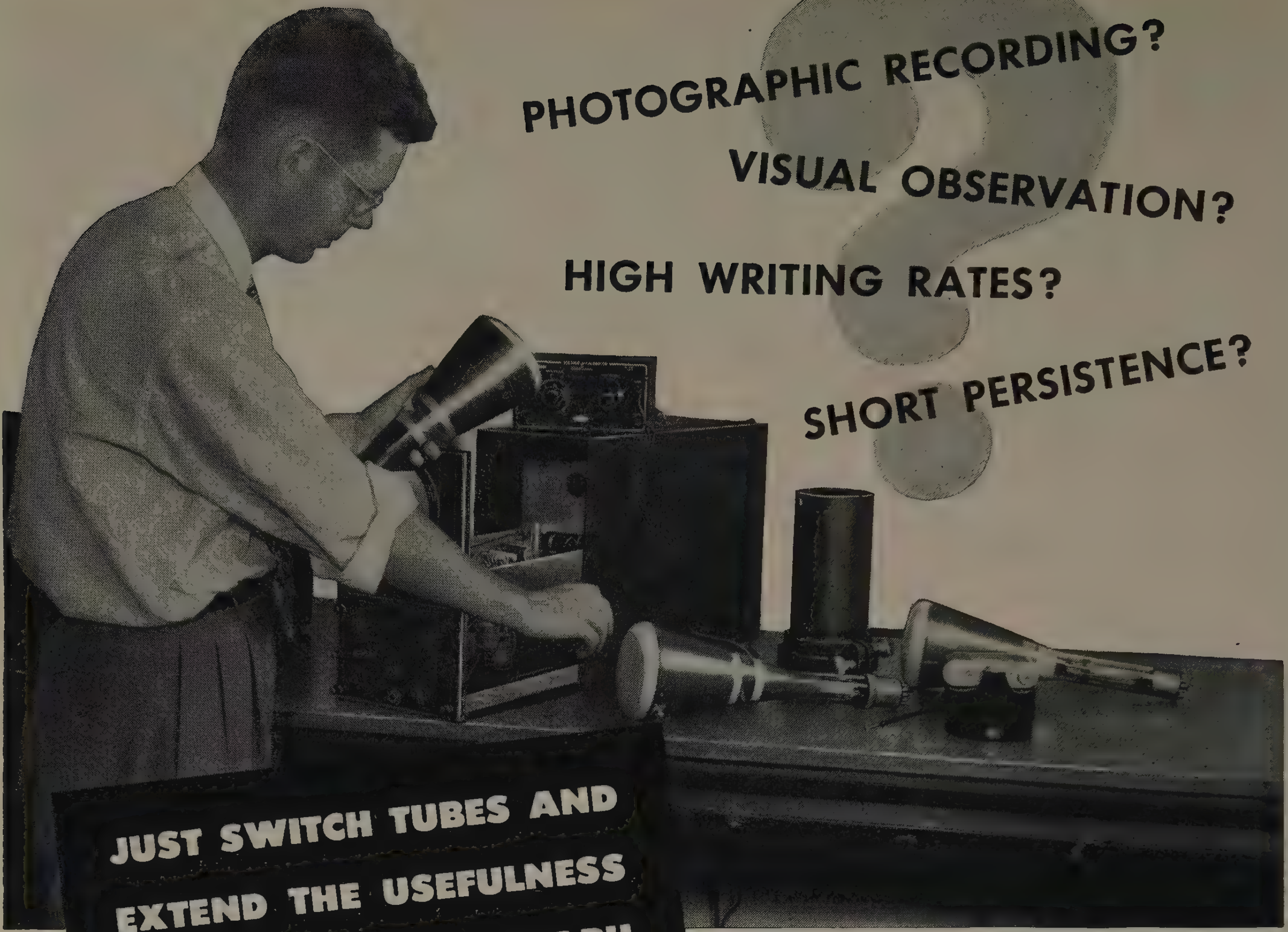

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P11: Short persistence blue. For recording high writing rates. Persistence time for energy drop to 50% is 10 microseconds.

➧ There's a screen for *every* oscillographic purpose. But *only* Du Mont makes *all* types of screens. By having that extra Du Mont tube with the right screen available, you can cover a wider range of applications more quickly and realize far greater value from your oscillograph, simply by switching tubes.

As a time-, trouble- and money-saver, that extra, dependable, high-quality Du Mont tube should be on hand when you need it. So why not buy it now while you're thinking about it?

And when replacing cathode-ray tubes, always remember that Du Mont tubes are made to RMA specifications and therefore fit any standard oscillograph.

➧***Use the right screen for the right job. Descriptive data on request.***

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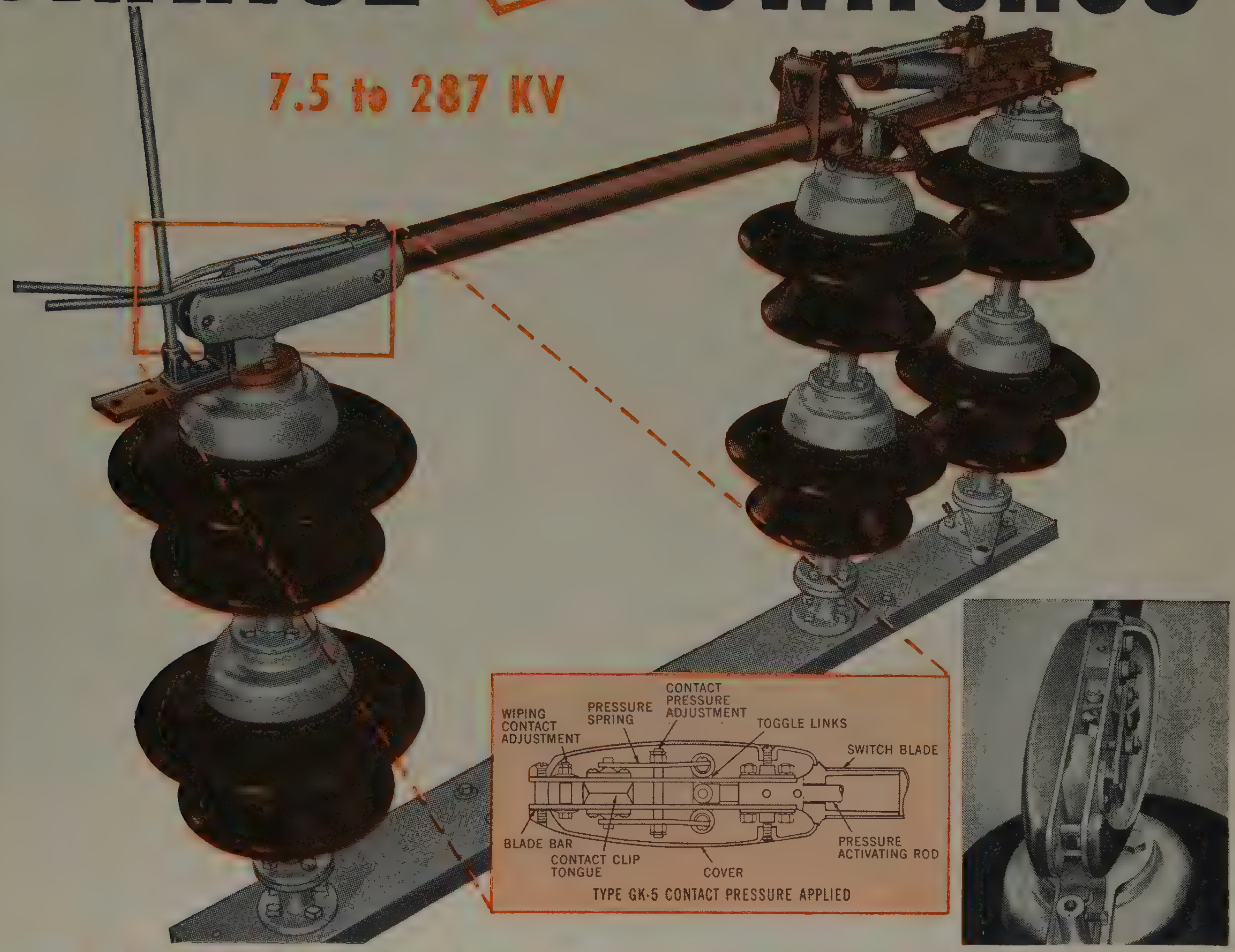
DUMONT *Precision Electronics & Television*

ALLEN B. DuMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J., U. S. A.

CHANCE GK-5 Switches*

7.5 to 287 KV



TYPE GK-5 CONTACT PRESSURE APPLIED

Long Life, High Pressure Area Contacts wipe clean without abrasion

CHANCE GK-5 Switches are fulfilling many big assignments on voltages up to and including 287 KV. They are performing with precision under widely varied climatic conditions. Designed by engineers who are experts on power switching operations—men who have many "firsts" to their credit for solving major switching problems—these switches are now available from coast to coast.

All details of the control mechanism of GK-5 switches have been designed to give years of smooth, dependable performance without field maintenance. Oilite bearings are used throughout . . . Switches for 69 KV and above have switch blade counter-balancing mechanism for easy gang operation . . . High pressure contacts are obtained by a simple toggle device.

● **LARGE AREA CONTACTS** give low contact resistance, maximum conduction of heat away from contacts during short circuits.

● **SILVER CONTACT SURFACES** — lower contact resistance by preventing copper oxidation.

● **GENTLE WIPING CLEANS CONTACTS.** The blade and clip contacts engage under moderate pressure during the blade movement. This wiping action cleans silver surfaces *without abrasion.*

● **HIGH PRESSURE AFTER CLOSING.** High pressure is applied after switch blade has completely closed. Pressure is released before blade travel starts, minimum contact resistance is obtained without surface abrasion, insuring long contact life.

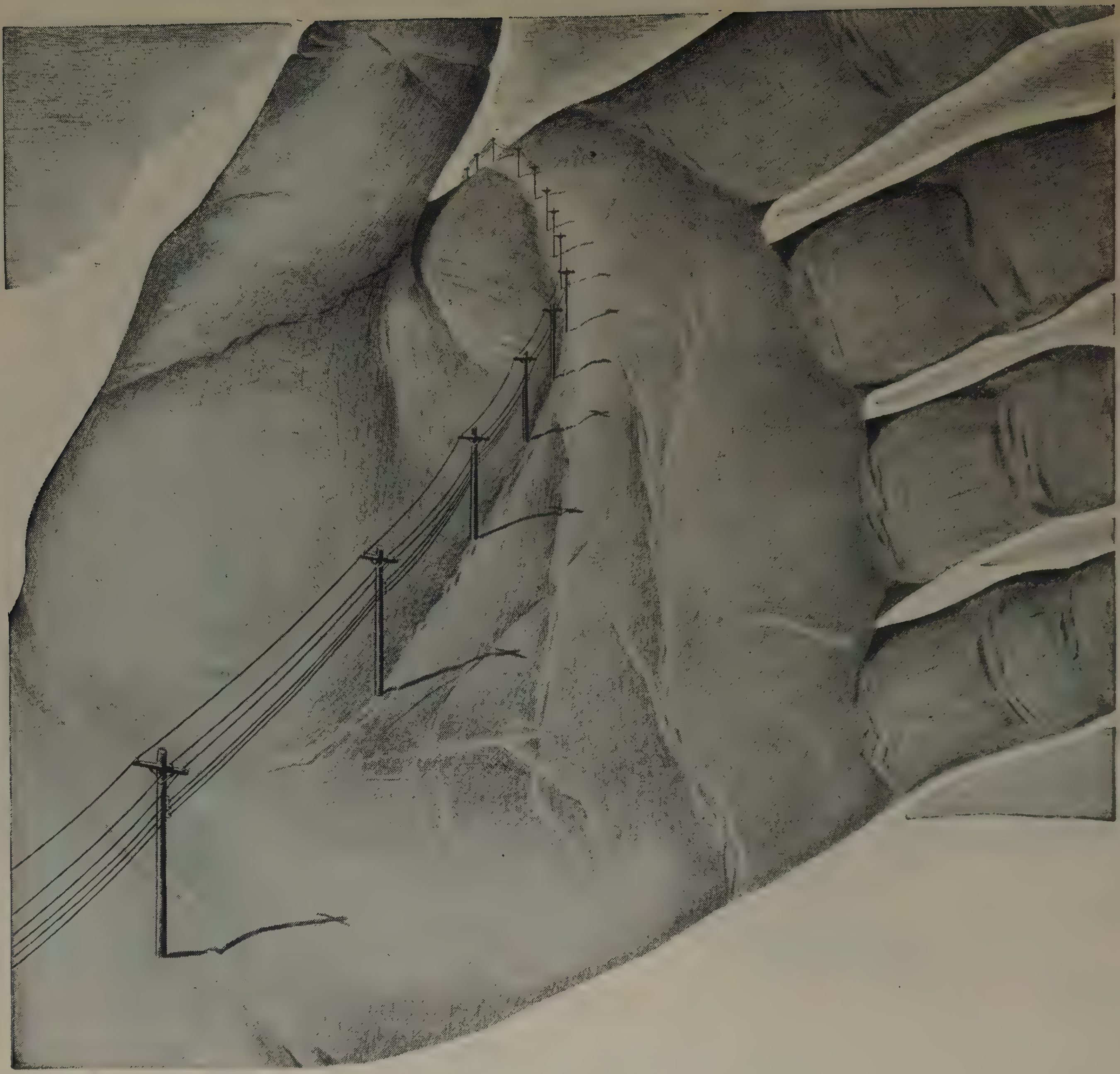
Diagram and cutaway photo show the contact mechanism of the GK-5. After closing motion is completed, control rod, actuated by a cam, causes toggle links to press against leaf springs which set the high pressure between contact surfaces.

C486

* CHANCE SWITCHES (FORMERLY BOWIE) ARE BACKED BY 42 YEARS OF SWITCH ENGINEERING AND MANUFACTURING EXPERIENCE.

A·B·CHANCE CO·

210 N. ALLEN STREET
CENTRALIA, MISSOURI · 815 TENNESSEE STREET
SAN FRANCISCO 7, CALIFORNIA



Make Duraline your Life "Line"!

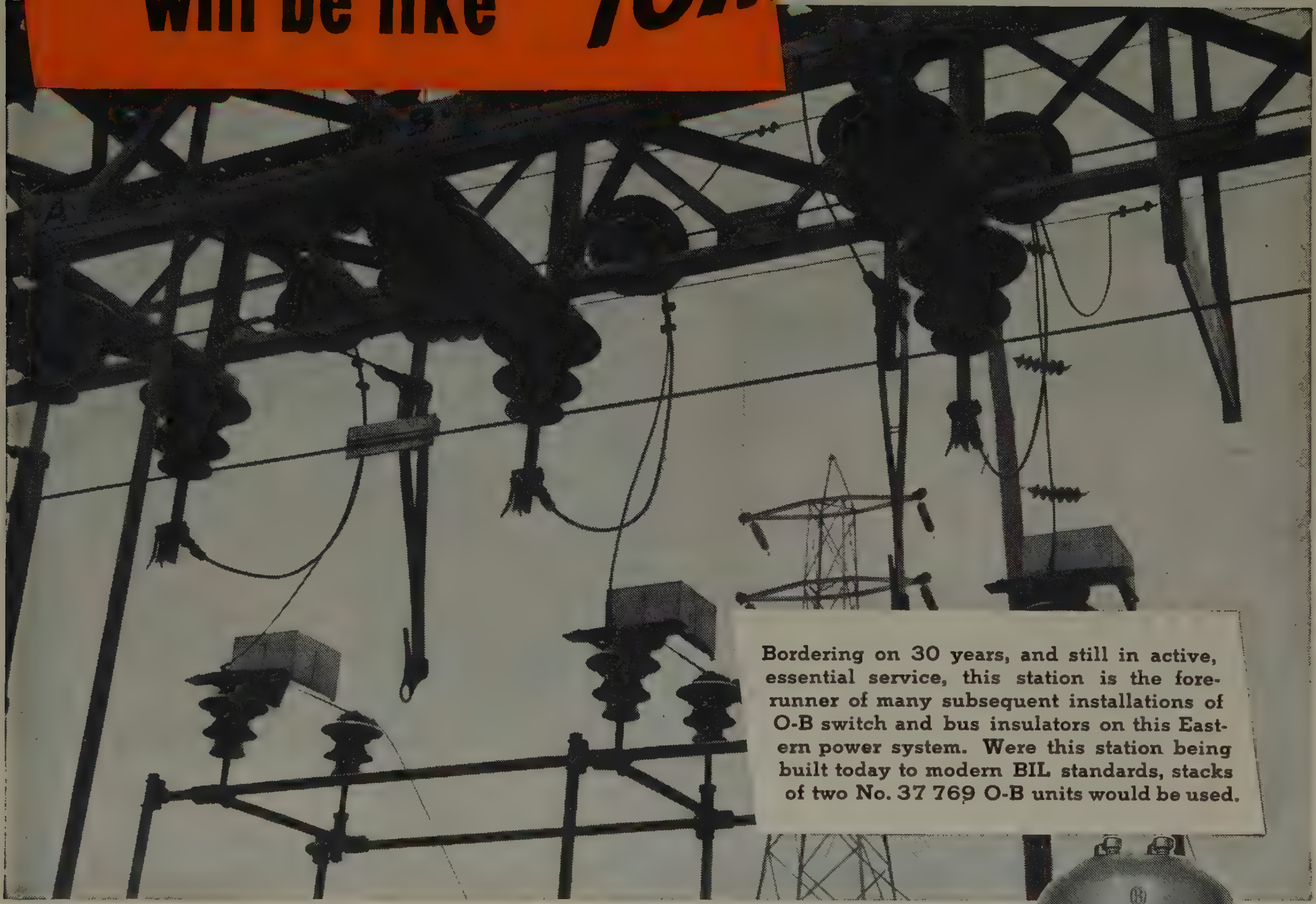
MILES AND MILES of Duraline* URC weatherproof wire, up for years, have proved the superiority of this unusual weatherproof.

Duraline is designed to provide vastly improved performance during emergency periods. Interlocked felted layers, combined with URC saturants and finishers, form a fibrous sheath that effectively retards moisture penetration—even during long periods of wet weather.

Here is weatherproof that is truly *weather-resisting*. For satisfied customers—and lower maintenance costs—invest in DURALINE URC WEATHERPROOF! Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y. 48466

ANACONDA
from mine to consumer

You can't specify what an insulator will be like TOMORROW!



Bordering on 30 years, and still in active, essential service, this station is the forerunner of many subsequent installations of O-B switch and bus insulators on this Eastern power system. Were this station being built today to modern BIL standards, stacks of two No. 37 769 O-B units would be used.

If you want to know how an insulator will be performing tomorrow, you must wait till tomorrow to find out! Specifications or standards don't cover this. They protect you only *today.* Your one safeguard for tomorrow is experience--experience that the manufacturer has *built into* the insulators; and experience that power companies have had *using them.* . . In the case of O-B switch and bus insulators, this experience goes back nearly thirty years in many instances, with the end no where in sight. Another fact: the great majority of O-B switch and bus insulator purchases are repeat orders *based on experience.* We know of no better proof of O-B durability--no better way of seeing into tomorrow when you buy insulators today.

Ohio Brass

2867-H

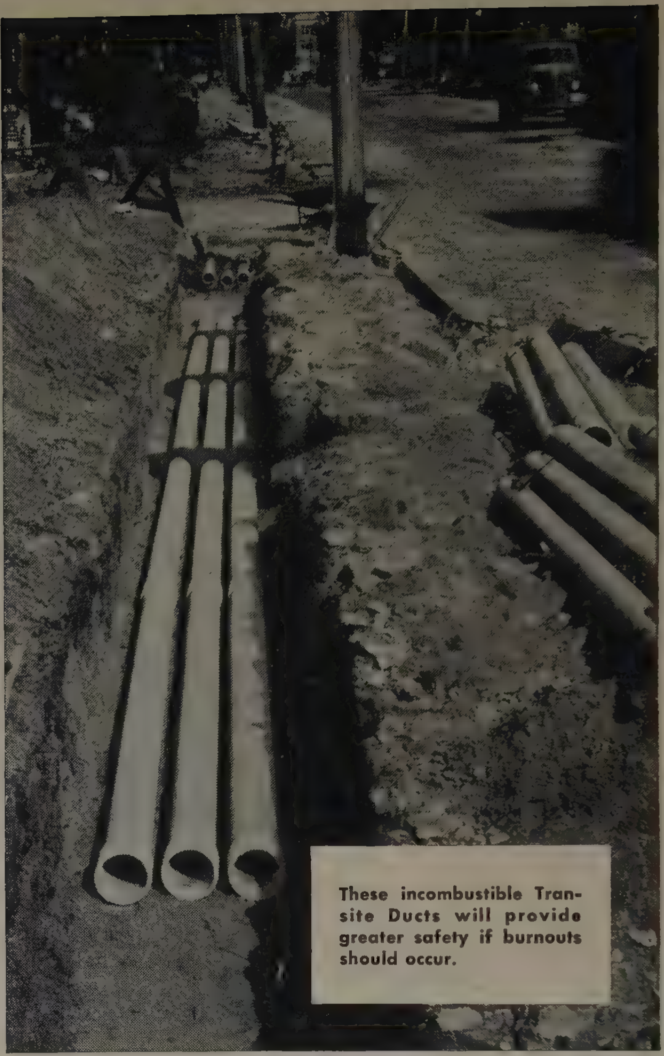
MANSFIELD, OHIO

CANADIAN OHIO BRASS CO., LTD., NIAGARA FALLS, ONT.

IF BURNOUTS SHOULD OCCUR—

Transite Ducts will not spread Smoke or Fumes

...because TRANSITE is inorganic—incombustible!



These incombustible Transite Ducts will provide greater safety if burnouts should occur.

Two great hazards ... smoke and fumes ... are less dangerous when you specify Transite Ducts for underground cableways. Made of asbestos and cement, Transite is inorganic and incombustible. It will not support flame, or contribute gases to a possible manhole explosion if burnouts should occur.

In addition to this vital safety factor, Transite Ducts offer these four other important advantages:

1. Easy to Install—Transite Ducts come in long, light lengths that are easy and economical to assemble and install.

2. Corrosion-Resistant—Transite is inorganic—cannot be affected by corrosive soils. It is made of asbestos and cement combined under great pressure into a permanently strong structure.

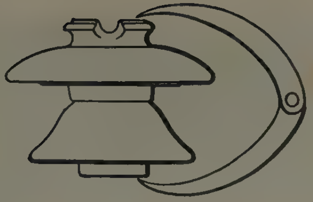
3. Immune to Electrolysis—Entirely inorganic and non-metallic, Transite Ducts are not affected by electrolysis or galvanic action.

4. Permanently Smooth Bore—Long cable pulls and replacements are easy with Johns-Manville Transite Ducts. And this smooth bore minimizes damage to cables.

For further information on how Transite Ducts can *increase the safety* and *cut the costs* of Cableway systems, write to Johns-Manville, Box 290, New York 16, New York.

Johns-Manville ***TRANSITE DUCTS***

CONDUIT for use without concrete
KORDUCT for concreting in

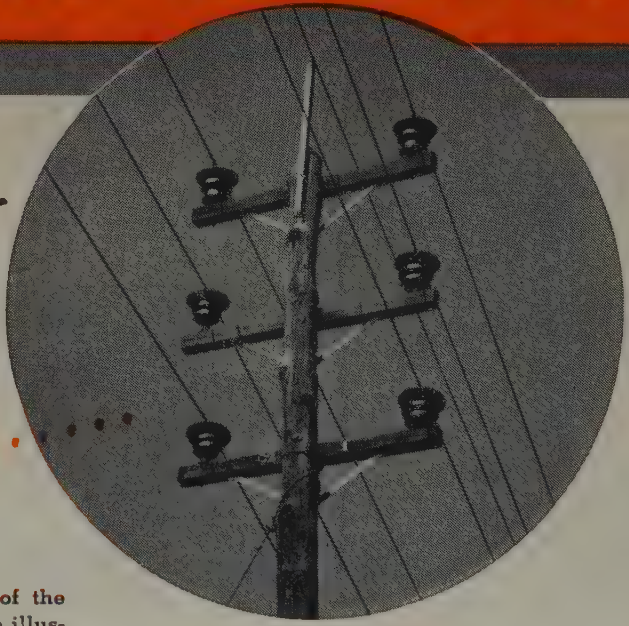


You can measure a Pintype's Size . . .

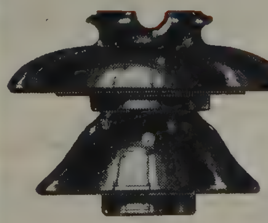
You can gauge a Pintype's Strength . . .

You can test its Dielectric Properties . . .

But YOU CAN'T TELL BY LABORATORY METHODS WHAT IT WILL BE DOING 30 OR 40 YEARS FROM NOW!



For the thing you want the most—long service life—you can depend upon this kind of evidence . . . . .



Today's equivalent of the insulators on the line illustrated is the Number 31855 pintype unit, rated nominally at 46 kv. Put this insulator on your lines--*and in your standards*--for long, trouble-free performance.

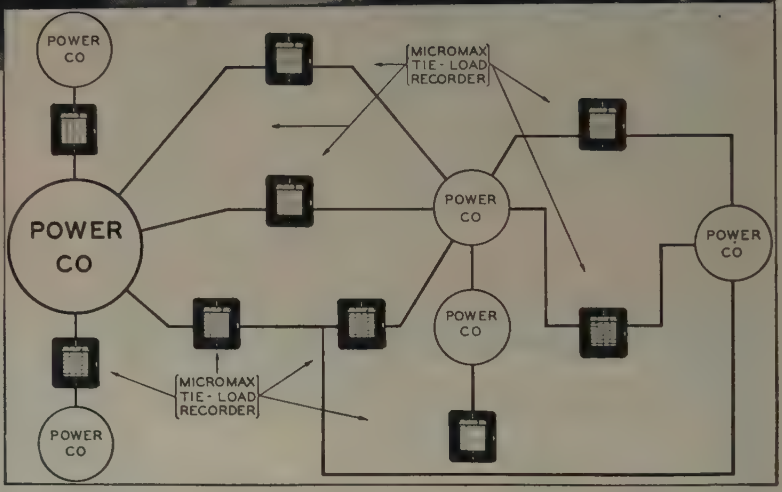
The O-B pintypes on this line have given complete satisfaction for 32 years--since 1916. This tradition of durability, plus many later improvements, is built into modern O-B pintypes.

Ohio Brass

MANSFIELD, OHIO

Canadian Ohio Brass Company, Ltd., Niagara Falls, Ont.

2862-H



Above: System operating room showing portion of a system map and 12 Micromax Load Recorders. At Right: Block diagram showing interconnections and 9 Micromax instruments which show tie-line load. The instruments shown in the photograph but omitted in the diagram are for tie-line bias, net interchange, and net system load.

Economic Distribution Of System Load

IS SPEEDED BY L&N TELEMETERING AND CONTROL

Tie lines radiate in various directions to the north, south and east from one of the country's big power systems, joining them to their power-company "neighbors." This pool of generating capacity carries a heavy interstate electric load, and the Company has found that L&N load telemetering and load-frequency control equipment is a "very definite help" in meeting the complex needs of system operation. The instruments help in two ways:

1. Operators can see continuously the load at any metered point. Because they can read either instantaneous load or load trends for some hours past, they can make on-the-spot decisions with speed and accuracy, and their instructions are carried out automatically.

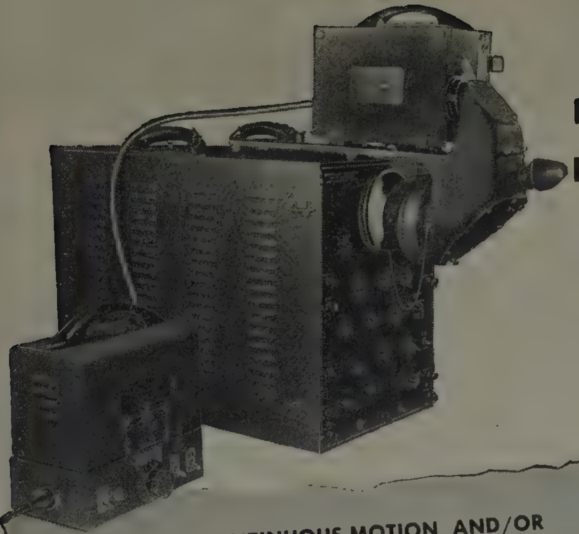
2. Executives can examine, at their convenience, the load records for any period of time, and can base broad operating and policy decisions on a fuller knowledge of the size, shape and peculiarities of system conditions.

Over ninety per cent of all interconnected capacity in the entire country uses L&N load-frequency equipment. Whether your facilities are interconnected or isolated; whether they need telemetering or just flat frequency control, there's an L&N equipment to suit your local conditions and handle all engineering and operating situations. We will send facts on request—you'll possibly need them in the future, if not now. Leeds & Northrup Co., 4962 Stenton Ave., Philadelphia 44, Pa.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LN LEEDS & NORTHRUP CO.

Jrl. Ad N-50-461(1)



For any kind of oscillographic recording . . .

DU MONT TYPE 271-A and/or DU MONT TYPE 314

Oscillograph-Record CAMERAS

to convert your oscillograph into a recording instrument

TYPE 314 CONTINUOUS-MOTION AND/OR SINGLE-FRAME CAMERA

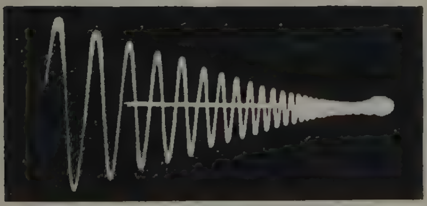
➧ In addition to single-frame exposures, the Du Mont Type 314 Oscillograph-Record Camera provides continuous-motion photography. Recommended for recording continuous, changing processes, and where variations to be studied require an extended period of time. Film speed electronically controlled within range of 1 inch per minute to 5 feet per second. Applicable to widest variety of uses such as study of Welding, Biology, Switches, Electric Shavers, Synchronous Motors, Fluorescent Lamps, Guided Missiles, Oscillator Drift, Voltage Stabilizers, Nuclear Physics, Hydraulics, Mechanics, Dynamic Unbalance, Cylinder Pressure, Acoustics, etc.

Type 314 Oscillograph-Record Camera, Cat. No. 1217-E (f/2.8 lens) $980; Cat. No. 1366-E (f/1.5 lens) $1,155; delivered in U.S.A.

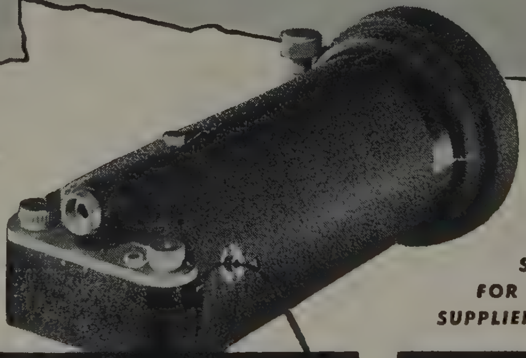
TYPE 271-A SINGLE-FRAME CAMERA

➧ For single-frame exposures of high-speed transients, or for multiple exposures to record a family of curves, the Du Mont Type 271-A Oscillograph-Record Camera is your ideal selection. And the cost is well within reach of the modest instrument budget. May also be used to good advantage with Du Mont Type 264-A Voltage Calibrator for amplitude and wave-form measurements. Equipped with f/3.5 lens. Uses standard 35 mm. film. And remember, this camera is readily fitted to any 5-inch oscillograph.

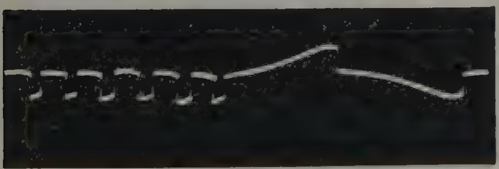
Type 271-A Oscillograph-Record Camera, Cat. No. 1216-E, $162.50 delivered in U.S.A.



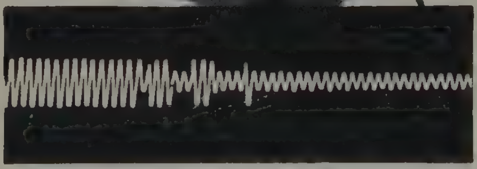
Typical high-speed recording: 2 mc transient (with Du Mont Types 281 and 286 Cathode-Ray Oscillographs using Type 271-A).



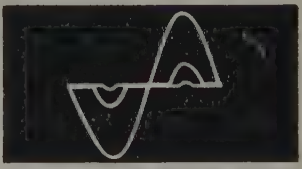
➧ DETAILED SPECIFICATIONS FOR EACH CAMERA, SUPPLIED ON REQUEST.



Output voltage of Type OB2 Voltage-Regulator Tube, with sudden applications of resistive load, using Type 314 Continuous-Motion/Single-Frame Camera.



Plot made on Type 314 of starting current of small synchronous motor. (Note variation in current as the rotor "hunts" for its synchronous speed).



Triple exposure made with Type 271-A while varying constants of peak-clipping circuit.

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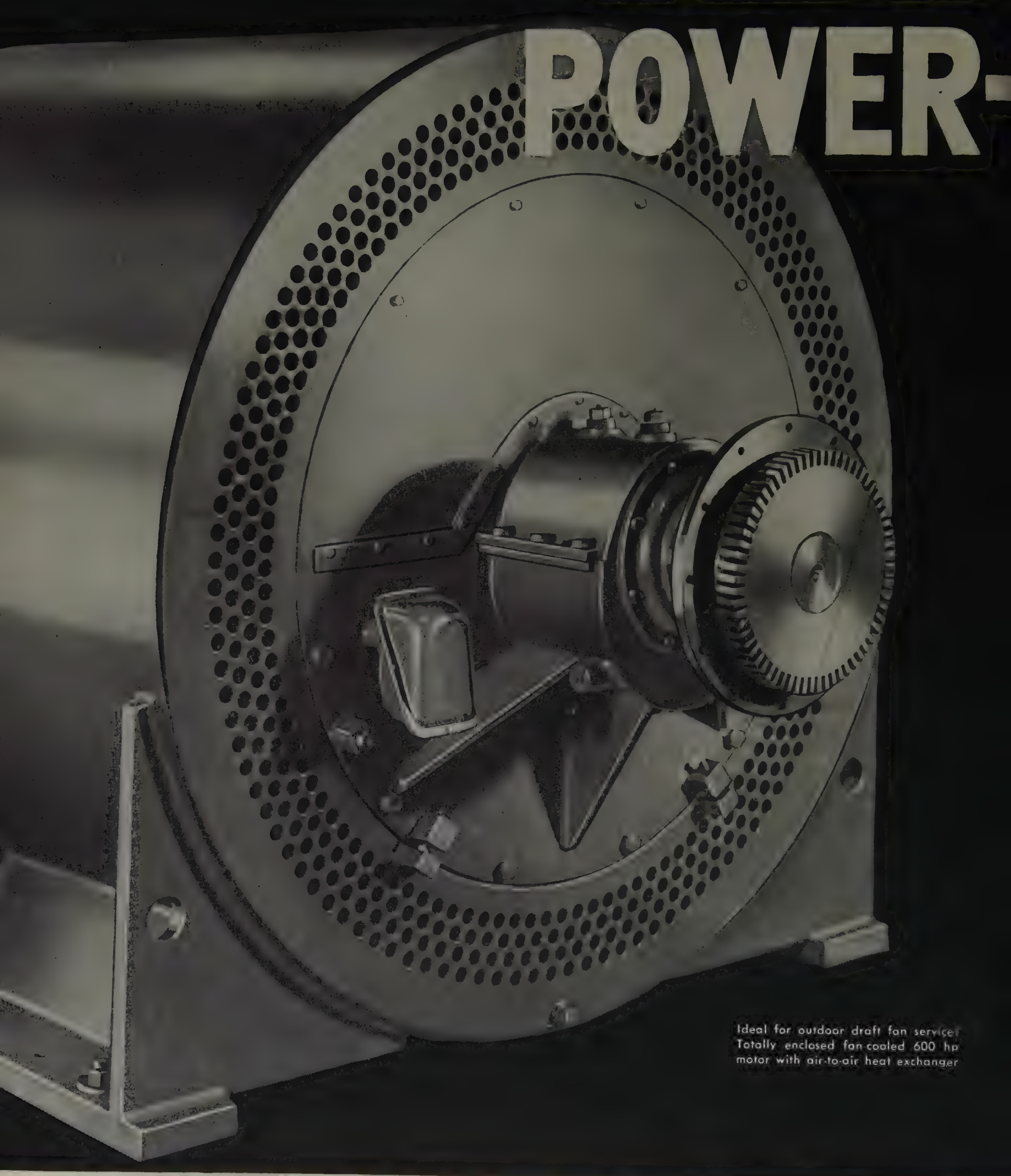
Allis-Chalmers Builds

POWER-



Ideal for outdoor draft fan service! Totally enclosed fan cooled 600 hp motor with air-to-air heat exchanger

BEFORE
— an installation showing the maze of wires, dangerous open switches, and the multiplicity of parts characteristic of early switchgear installations.

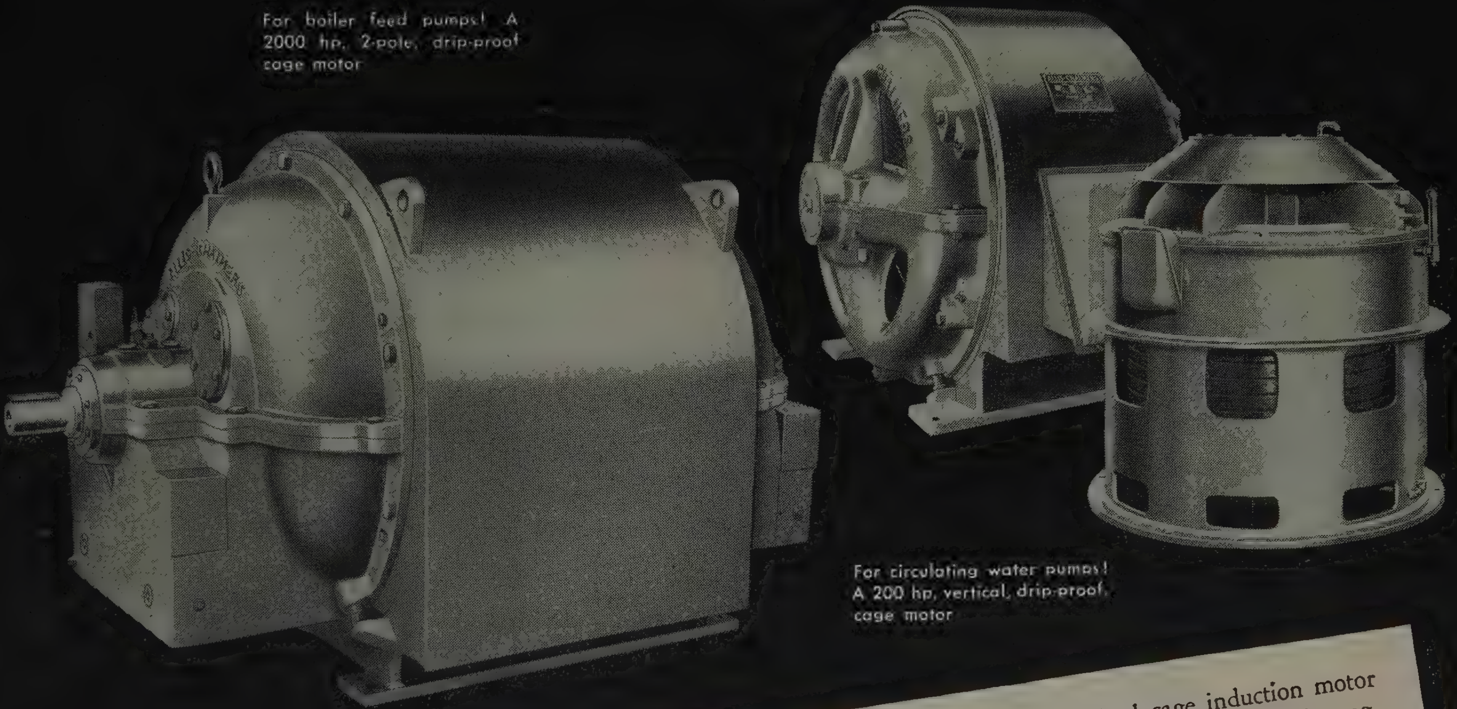
AFTER
modernization! Allis-Chalmers latest vertical lift, metal-clad switchgear demonstrates the new conception of neatness, safety, compactness.

ALLIS-

Pioneers in Power and

for Progress in Electric Power — Typical Example:

HOUSE MOTORS



For indoor draft fans! A 350 hp cage motor

For boiler feed pumps! A 2000 hp, 2-pole, drip-proof cage motor

For circulating water pumps! A 200 hp, vertical, drip-proof, cage motor

— for conveyors, pumps, compressors, boiler fans, and coal handling—"A-C" motors 1/2 hp to largest!

SIXTY YEARS of service to the electric power industry gives Allis-Chalmers engineers an intimate knowledge of your operating problems. During these years "A-C" has developed the country's largest line of major equipment for electric power.

Included are power-house motors . . . designed with unusual care. These motors have many maintenance saving features of interest to operators.

A case in point is the totally enclosed fan-cooled motor with air-to-air heat exchanger. It's ideal for those dirty locations outdoors or indoors, driving large auxiliaries. *The only motor of its type!*

Internal air is circulated around tubes arranged about the circumference of the stator frame. Motor heat, transferred to the tubes is dissipated by cooling air blown through the straight, easy-to-clean tubes. No outside air can contact enclosed parts of the motor.

These design details of the two pole, squirrel cage induction motor illustrate another point . . . the ruggedness of A-C design. *"Tear drop"* design of *rotor bars* gives excellent starting characteristics — makes bars tight in the laminations and in the end rings — eliminates rotor rod and end ring failure. *End rings* — forged from copper alloy castings. Bearings — liberal in design and easy to dismantle for inspection.

These are typical examples of the advanced design thinking that makes Allis-Chalmers a good name to know in electric power. ALLIS-CHALMERS, MILWAUKEE 1, WISCONSIN.

ALLIS-CHALMERS A-C MILWAUKEE

A 2441

CHALMERS

Electrical Equipment From Generation Through Utilization

TO MEASURE NOISE

ANYONE can learn to use the Type 759-B Sound-Level Meter with a few minutes' practice. With it, accurate measurements of practically any level of noise encountered in industry can be measured accurately.

Throughout industry thousands of these instruments are in use daily for such sound measurements as

- **SURVEYING STREET TRAFFIC NOISES**
- **OPERATING PUNCH PRESSES, MILLING MACHINES, LATHES AND OTHER FACTORY EQUIPMENT**
- **DETERMINING EFFECTIVENESS OF SOUND-PROOFING MATERIALS IN OFFICES, FACTORIES, AIRPLANE CABINS, RAILROAD TRAINS**
- **OPERATING OFFICE EQUIPMENT SUCH AS ADDRESSING MACHINES, AIRCONDITIONING SYSTEMS, ADDING AND CALCULATING MACHINES**
- **PLOTTING SOUND DISTRIBUTION IN THEATERS**
- **COMPARING THE OVER-ALL NOISE PRODUCED BY MECHANICAL AND ELECTRICAL MACHINES OF DIFFERENT MANUFACTURE.**

The G-R Sound-Level Meter is very simple to use. It is only necessary to turn on the instrument, hold it near the source of noise, adjust the DECIBELS knob until the meter reads on scale, and then add the decibel reading of the meter to the setting of the knob and the answer is in decibels of noise to an accuracy of ±1 per cent.

Features of the Type 759-B meter include:

NON-DIRECTIONAL PICK-UP — responds properly over a wide range of frequencies.

UNUSUAL SENSITIVITY — range of +24 db to +140 db above the A. S. A. standard reference level.

SLOW-FAST METER — switch selects either SLOW or FAST meter damping.

STABLE CALIBRATION — can be checked easily from any 115-volt a-c line.

NON-MICROPHONIC — special tube suspension eliminates microphonic noises and resulting errors.

NON-MAGNETIC — no inductance coils or transformers to cause serious errors from electrical pick-up

TYPE 795-B
SOUND-LEVEL METER . . . $320

WRITE FOR "THE NOISE PRIMER"

A 54-page booklet on noise and vibration measurement and analysis . . . . IT'S FREE!

SIMPLY

ACCURATELY

CONVENIENTLY

- **SOUND LEVEL RANGE +24 TO +140 DB**
- **ACCURATE TO ±1 DECIBEL**
- **NON-DIRECTIONAL PICK-UP**
- **COMPLETELY SELF-CONTAINED**
- **PORTABLE—WEIGHS ONLY 22 POUNDS WITH BATTERIES**

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

90 West St., New York 6 920 S. Michigan Ave., Chicago 5 950 N. Highland Ave., Los Angeles 38

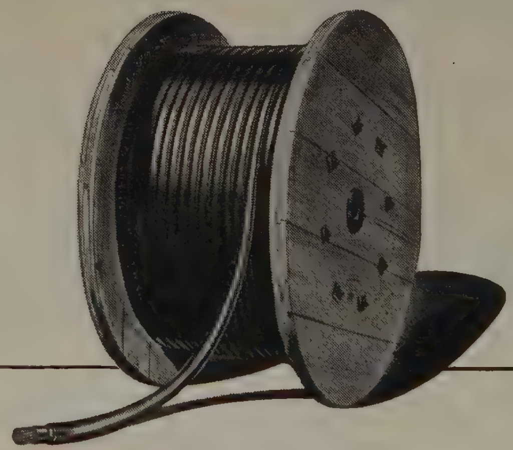
FIGURE IT IN ALUMINUM

For new plants, for rewiring for additional load—you'll save *big money* if you *figure it in aluminum!*

The lighter weight of insulated wire and cable with Alcoa E.C.* Aluminum Conductor means startling differences in wiring costs. A 500 mcm insulated aluminum cable weighs less than half the weight of an identical copper cable.

First costs are lower. Transportation costs are less. Installation is easier. Mechanical joints are easy with standard connectors for aluminum—soldering, too, with Alcoa Solder and Flux. *Welded* terminals and splices are highly efficient and easily made with aluminum.

Alcoa makes light, strong, conductive E.C. Aluminum; leading wire manufacturers draw, strand and insulate it, sell it under their own trademarks. They have it now. ALUMINUM COMPANY OF AMERICA, 2149 Gulf Building, Pittsburgh 19, Pennsylvania. *E. C.: *Electrical Conductor* Aluminum



The BIG DIFFERENCE is in your COSTS!

YOUR SUPPLIER HAS IT!

Insulated and sold by leading wire manufacturers

ALCOA EC ALUMINUM

ALCOA ALUMINUM

FOR ELECTRIC WIRE AND CABLE

THERE'S PROFIT FOR YOU IN

THE TIME AND MONEY-SAVING QUALITIES OF

ARNOLD

PERMANENT MAGNETS

Several avenues of profit are open to you in Arnold Permanent Magnets. You can improve the performance and overall efficiency of equipment. You can increase production speed, and in many cases reduce both weight and size. And most important, you can maintain these advantages over any length of production run or period of time, because Arnold Permanent Magnets are completely quality-controlled through *every* step of manufacture—from the design board to final test and assembly. You'll find them unvaryingly uniform and reliable in every magnetic and physical sense.

It's our job to help you discover and then fully attain these benefits. Arnold Products are available in all Alnico grades and other types of magnetic materials—in cast or sintered forms, and in any size or shape required. Our engineers are at your command—check with our Chicago headquarters, or with any Allegheny Ludlum branch office.

W&D 1298

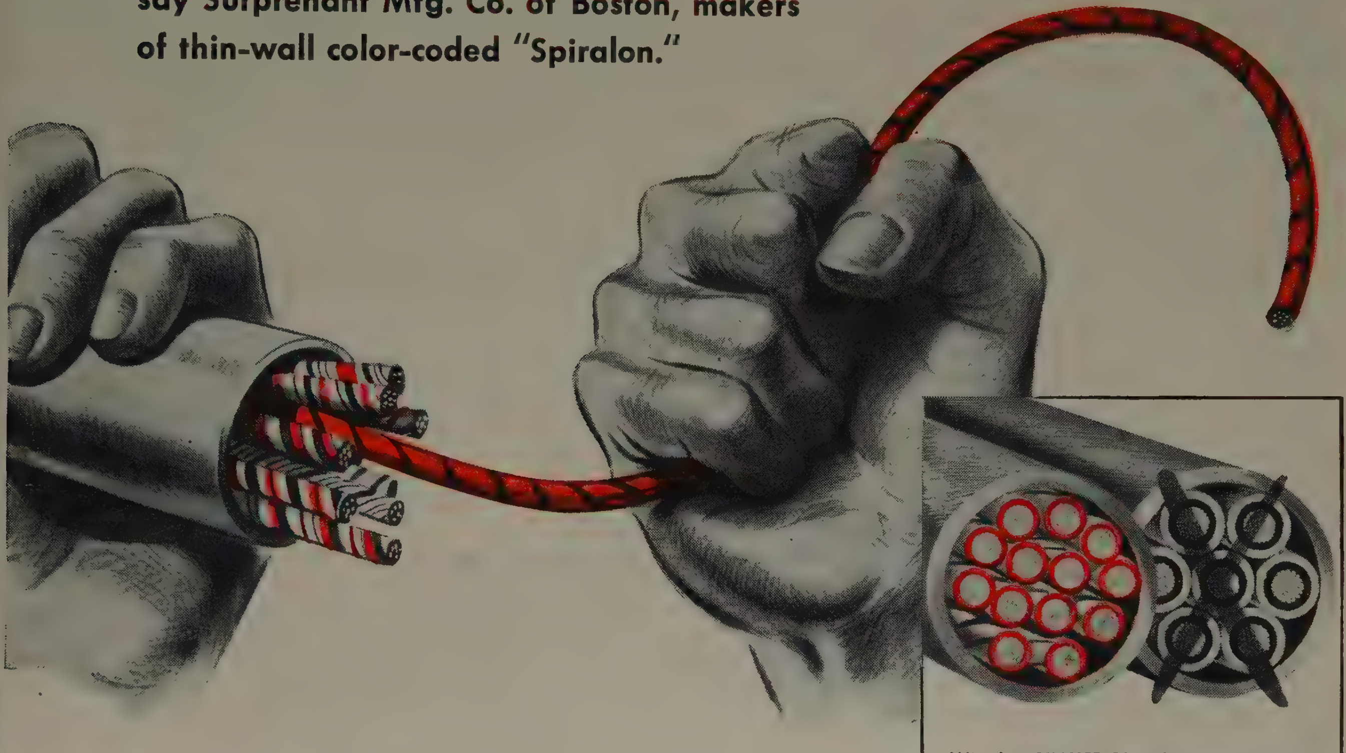
AL
ARNOLD

THE ARNOLD ENGINEERING CO.
Subsidiary of **ALLEGHENY LUDLUM STEEL CORPORATION**
147 East Ontario Street, Chicago 11, Illinois
Specialists and Leaders in the Design, Engineering and Manufacture of PERMANENT MAGNETS

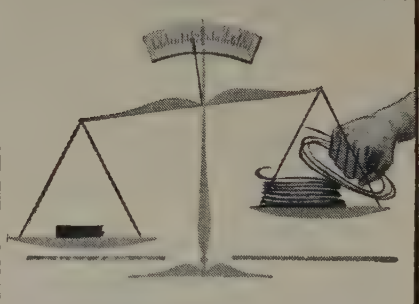
Why are big wire producers using Du Pont NYLON plastic?

"Unsurpassed as a protective jacket for wire,"

say Surprenant Mfg. Co. of Boston, makers of thin-wall color-coded "Spiralon."

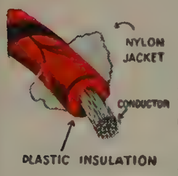


Wire has **SMALLER DIAMETER,** permits more wires in limited area.



Wire is **LIGHT IN WEIGHT,** and resists heat, oils, water, chemicals, abrasion and flexing.

"Jacketing of Du Pont NYLON helps us produce a color-coded wire with fungus- and abrasion-resistance, extra smoothness for easier pulling, and many other advantages."



"Our new 'Spiralon' wire is available in many thousands of distinct color combinations, making identification easy even in the most complex installations," report Surprenant Manufacturing Company. "It consists of a conductor, color-coded plastic insulation, and a transparent protective jacket of Du Pont nylon. The nylon cover can be applied easily and rapidly. It's *extra smooth.* It's tough and long lasting. It resists heat, oils, many chemicals, abrasion, and flexing. And nylon helps us produce a wire with *smaller diameter* and *lighter weight.* We feel it is unsurpassed as a thin-wall extruded covering."

Know these facts—for profits

Wire, cable and many other electrical products today are *better* products, because of Du Pont nylon. This Du Pont plastic can be molded or extruded, and colored to fit specifications. For your own good—don't overlook its remarkable properties. Write for free booklet, "65 Success Stories of Product Improvement." Filled with helpful facts. Just address: E. I. du Pont de Nemours & Co. (Inc.), Plastics Dept., Room 166, Arlington, N. J.

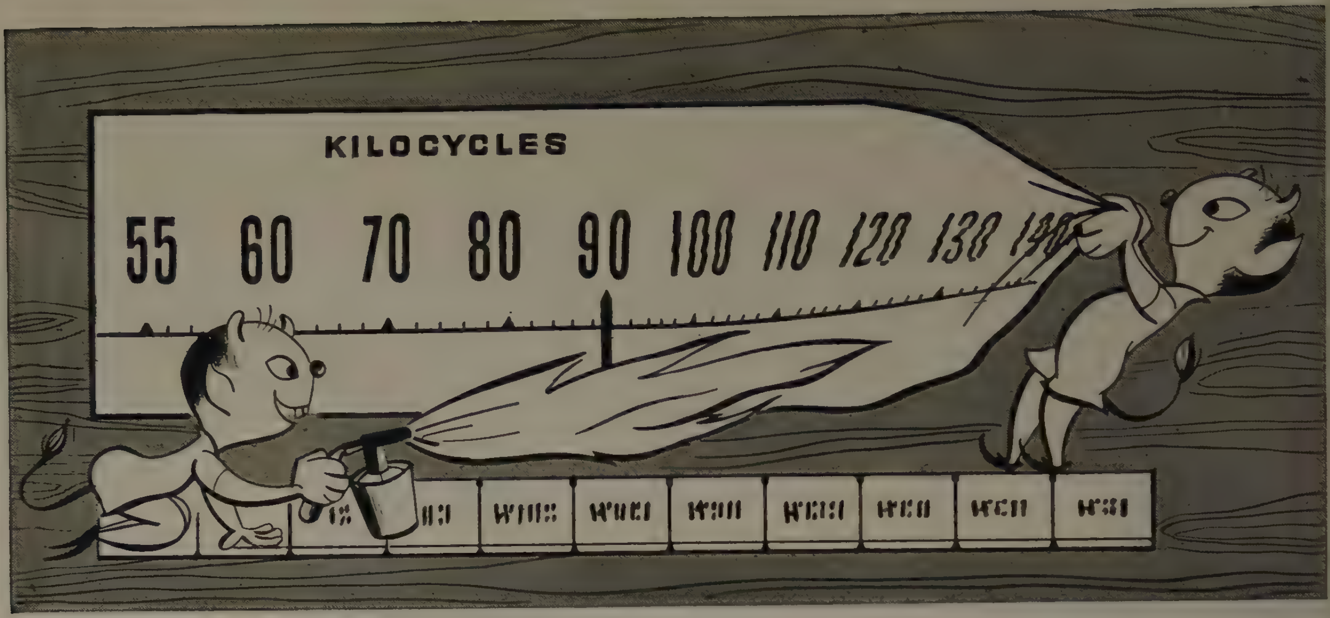
TUNE IN Du Pont's "Cavalcade of America"—Monday Evenings—NBC coast to coast-

CHECK THESE 7 BASIC FEATURES OF NYLON FOR ELECTRICAL USES

1. Good flexibility
2. High tensile strength
3. Extreme toughness
4. Abrasion resistance
5. Resistance to permanent set
6. Chemical resistance
7. Ability to be molded or extruded . . . colored or in natural color.

DU PONT
REG. U. S. PAT. OFF.
Plastics

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY



TEMPERATURE DRIFT

(and how to avoid it)

To get negligible temperature drift in your I-F transformers, the electrical characteristics of the *cores* have to be virtually *constant throughout the entire use-range of temperature.*

But a core can be no more constant—can have no greater *temperature stability*—than the powder it's made of. That's why it's important to have cores made of G. A. & F. Carbonyl Iron Powders.

These powders, made by G. A. & F.'s exclusive, patented carbonyl process, have a *unique* degree of temperature stability, and in direct comparison tests proved themselves superior to all other magnetic powders.

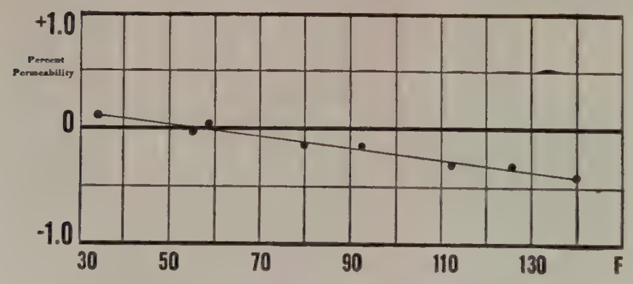
G. A. & F. Carbonyl Iron Powders for high frequency cores offer these advantages to the electronics industry:

1. When used at radio frequency, G. A. & F. Carbonyl Iron Powders are generally superior in coefficients of eddy current loss and residual loss. These low losses usually make for high Q.
2. G. A. & F. Carbonyl Iron Powders are also superior in coefficients of magnetic and temperature stability.
3. In comparison with air-cored coils, G. A. & F. Carbonyl Iron Powder-cored coils permit considerable savings in volume, weight, and wire-length, along with great increases in inductance and Q.

➡ Ask your core manufacturer for information about G.A.&F. Carbonyl Iron Powders. Or write direct to: Antara Products, 444 Madison Avenue, New York 22, N. Y. Dept. 61.

PERMEABILITY CHANGE DUE TO TEMPERATURE

(For uncompensated toroid of G. A. & F. Carbonyl Iron Powders)



(NOTE: Applicable to grades E, TH, and SF)

These unique properties tell why G. A. & F. Carbonyl Iron Powders are superior:

PROPERTY	ADVANTAGE
Spherical structure	Facilitates insulation and compacting
Concentric shell structure (some types only)	Low eddy current losses
High iron content	Exceptional permeability and compressibility
Absence of non-ferrous metals	Absence of corresponding disturbing influences
Relative absence of internal stress; regular crystal structure	Low hysteresis loss
Spheres of small size	Low eddy current losses; usable for high frequencies
Variations of sphere size	Extremely close packing

G. A. & F. CARBONYL IRON POWDERS

An Antara® Product of General Aniline & Film Corporation

What is one of the basic requirements of a "good" instrument?
Westinghouse
50
100
150
200
AMPERES

SPRINGS that remain constant for life

...one of the reasons why Westinghouse instruments are good!

Westinghouse-made springs keep their shape and torque for life. "Spring set" is eliminated. Phosphor-bronze alloys are precision-rolled to extremely close tolerances. Calibration accuracy is uniform and permanent over the entire scale length. Rigid torque inspection assures uniform tension characteristics for every type of service. Each spring is tested individually.

And so it is with every other component of Westinghouse instruments . . . each part especially perfected for harmonious relation with all other parts . . . and all parts designed and built by one manufacturer . . . Westinghouse. Such undivided responsibility of manufacture accounts for the life-long accuracy of all Westinghouse instruments.

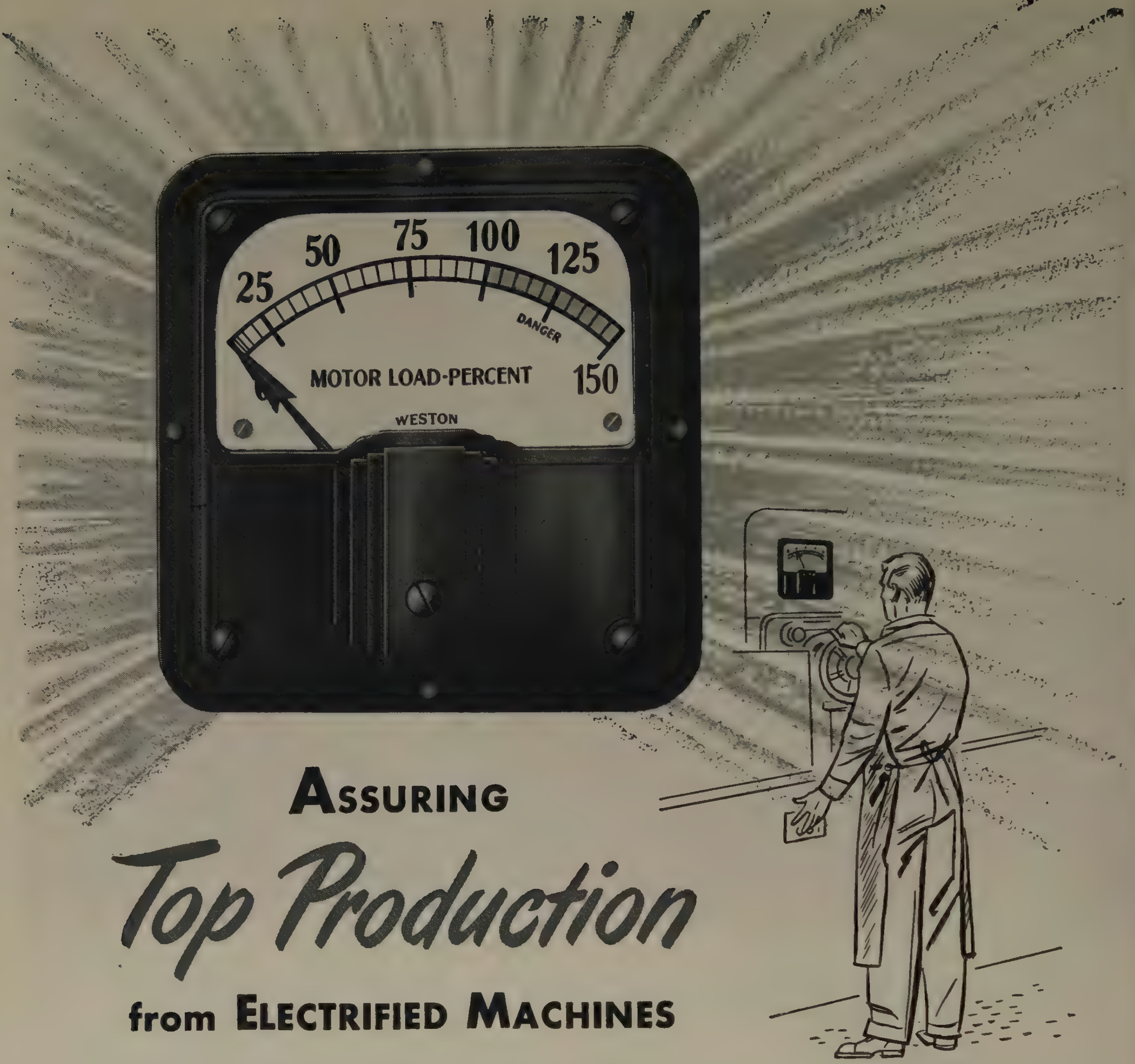
For any problem concerning electrical instruments and their application, consult a Westinghouse instrument specialist. Call your nearest Westinghouse office or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-40351

* * *

IMMEDIATE DELIVERIES on many instruments . . . others up to 90 days.

Westinghouse INSTRUMENTS
PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Built for Unfailing Performance



ASSURING

Top Production

from ELECTRIFIED MACHINES

By integrating the WESTON "per-cent load" ammeter or wattmeter into the machine, designers now make it easy for operators to secure *optimum production* from machine tools and other motor-driven equipment. This instrument continuously provides operators with the following indications:

MAXIMUM SAFE LOAD . . . *reduces tool breakage.*

CHANGING LOAD . . . *indicates need for sharpening or resetting tools, redressing grinding wheels, etc.*

OVERLOAD . . . *permits corrections before serious troubles occur.*

Installed on milling machines, grinders, polishers, turret lathes, automatics, etc., the "per-cent load" indicator is proving a valuable aid in *increasing production . . . providing uniformly high quality with fewer rejects . . . assuring longer life from motors and tools.*

Consult your nearest WESTON representative, or write Weston Electrical Instrument Corp., 664 Frelinghuysen Ave., Newark 5, N. J.

WESTON
Instruments

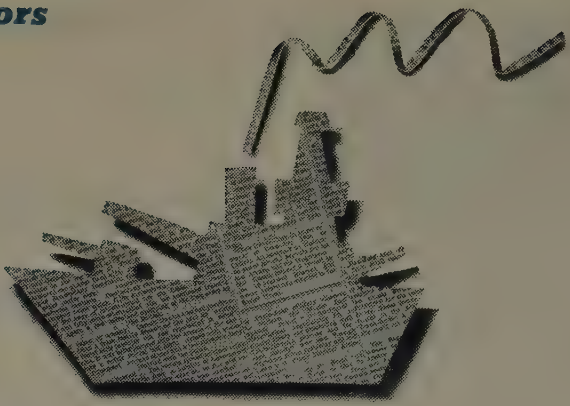
Albany • Atlanta • Boston • Buffalo • Charlotte • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Jacksonville • Knoxville • Little Rock • Los Angeles • Meriden • Minneapolis • Newark
New Orleans • New York • Philadelphia • Phoenix • Pittsburgh • Rochester • San Francisco • Seattle • St. Louis • Syracuse • In Canada, Northern Electric Co., Ltd., Powerlite Devices, Ltd.

when specifying capacitors

which test

do you go by . . .

a ten hour lab record?



or a

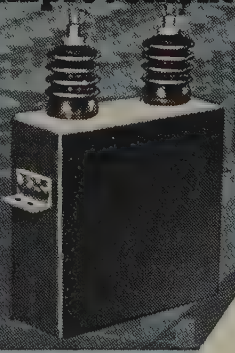
ten year service

record?

cornell-dubilier capacitors

for power-factor improvement

Dependability is a word of exact meaning to engineers. That's why a 10 year record of power plant service with Cornell-Dubilier Capacitors means more to you than a short range lab test for questionable units. C-D's record of achievement speaks for itself: *with over 3,500 C-D power-factor installations in the field, few have needed even minor repairs when operated as long as 10 years.* Here's real dependability — in the full, exact meaning of the word. Contact your C-D field man for experienced power-factor improvement counsel. Cornell-Dubilier Electric Corporation, Dept. B6, South Plainfield, New Jersey. Other plants in New Bedford, Worcester, Brookline, Massachusetts; and Providence, Rhode Island.



15 kva., 7,960 v., Single Phase, 60 Cycle, Pole-Type Capacitor

CORNELL-DUBILIER • WORLD'S LARGEST MANUFACTURER OF CAPACITORS

Follow the leaders.
Demand dependable C-D Capacitors
for your system.

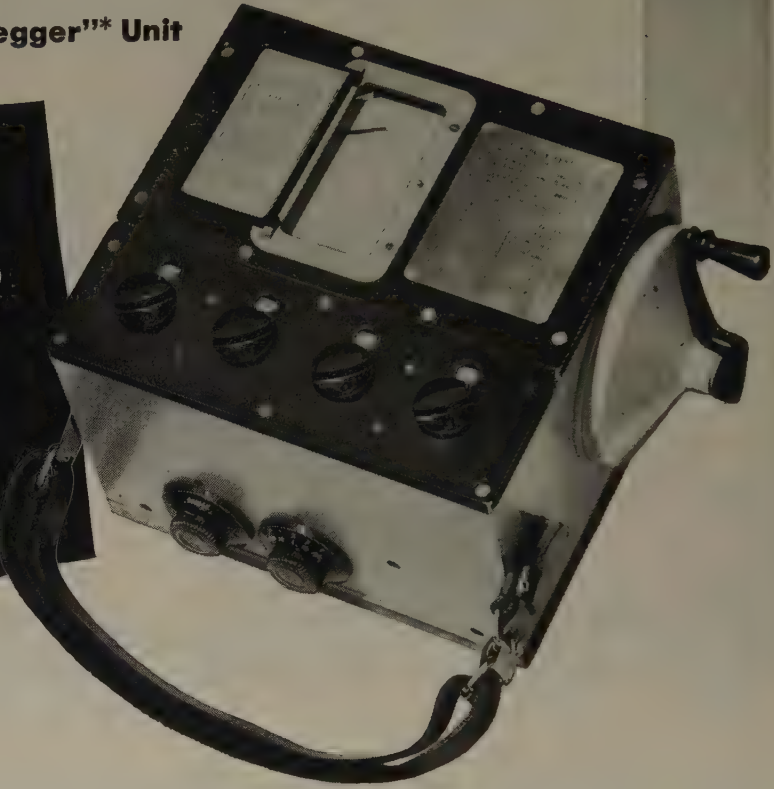
Everything you need...

for Electrical Resistance Measurement

FROM .01 OHM UP TO 1000 MEGOHMS

In One "Megger"* Unit

The "BRIDGE-MEG" Resistance Tester



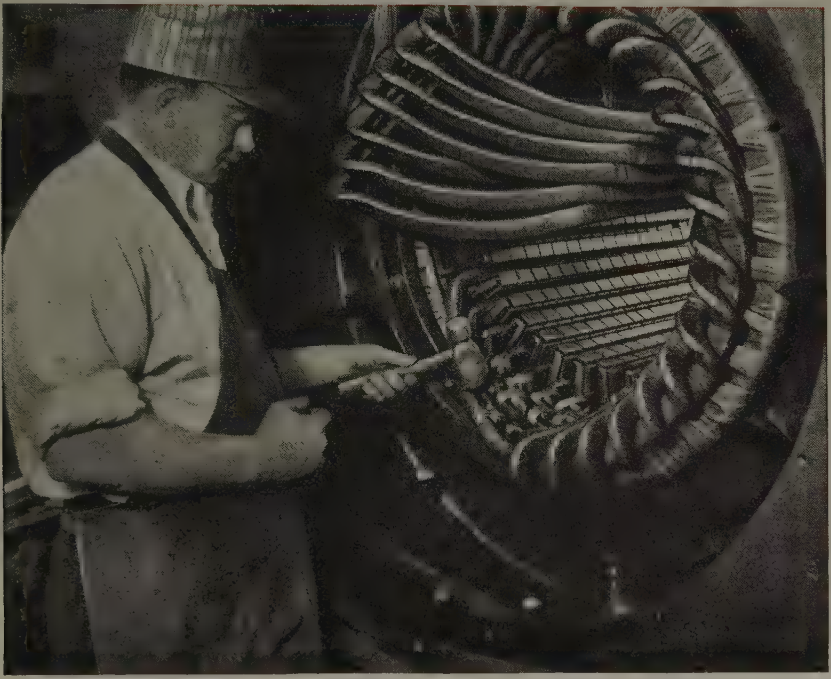
Here is a combined "Megger" Insulation Tester and Wheatstone Bridge that has been proved by years of service, and that can be used to measure almost any resistance encountered in routine maintenance work—anywhere and at any time. It measures *conductor resistance* from as low as .01 ohm up to 999,990 ohms, and can be supplied with Varley Loop test facilities. It measures *insulation resistance* from 10,000 ohms to as high as 1000 megohms. A rotary switch permits instant selection between insulation resistance and Wheatstone Bridge functions. Having a self-contained hand generator, it is independent of batteries or outside source of power supply. Various ratings, 250, 500 or 1000 volts d-c. The set is portable, compact and simple to operate.

The "Bridge-Meg" Resistance Tester is fully described, fully illustrated in a 12-page bulletin available to you at no obligation. We would be pleased to send you a copy. Ask for Bulletin 21-60EE.

*REG. U. S. PAT. OFF.

JAMES G. BIDDLE CO.
Electrical & Scientific Instruments
1316 ARCH STREET, PHILADELPHIA 7, PA.

to help you...
beat motor heat!



When overwork and ambient heat keep motor temperatures up, burnouts can be a constant threat to operation. To beat motor heat — to prevent frequent motor overhaul — insist on Deltabeston* magnet wire for every winding job.

To help you beat the particular heat conditions your motors have to meet, Deltabeston is built in types for all high-temperature conditions up to 200 C. Made of purified asbestos, firmly bonded to high-conductivity copper, Deltabeston magnet wires are flexible for easy winding, heat- and moisture-resistant for long service. Deltabeston magnet wires are manufactured in all sizes and shapes.

Whether you do your own rewinding or send it to an outside shop, always specify heat-beating Deltabeston magnet wire to beat motor heat.

To help you select

Now, to help you select the proper magnet wires for your heat problem, an informative 20-page booklet is ready for mailing. It contains information on the heat-beating Deltabeston line and a handy selector chart. Just fill out the coupon, and mail it to us for your free copy.

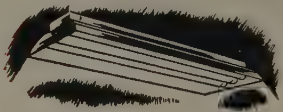
**Trade-mark Reg. U. S. Pat. Off.*

GENERAL ELECTRIC

HI-AMBIENTS

Practical product suggestions from your Deltabeston Distributor

FOR FLEXIBLE LEADS . . . on heavy apparatus that involves hot work, such as electric furnaces, cranes handling hot metals, and the like, Deltabeston motor lead cable, YK-2253, is a popular choice. Insulated with an impregnated wall of felted asbestos and asbestos braid, it resists heat, flame, oil, and corrosive vapors up to 125 C (257 F).



FLUORESCENT FIXTURES . . . need heat-resistant wiring in and around the ballast. For those located in hot, humid places, *all* the wiring should be heat resistant. Why not make your installation with the same type of Deltabeston wire which ballast and fixture manufacturers use?

WIRING JET PLANES . . . may be a long way from your business, but the choice of a Deltabeston aircraft wire for this extra-severe duty helps to explain why so many folks turn to us for solutions to "impossible" insulation requirements.

DELTABESTON

Wires and Cables

built to beat the heat

Section Y6-420
General Electric Company
Bridgeport 2, Connecticut

Please send me the new, free booklet on Deltabeston magnet wires.

Name__________________Title__________

Company____________________________

Address____________________________

City______________Zone_____State_______

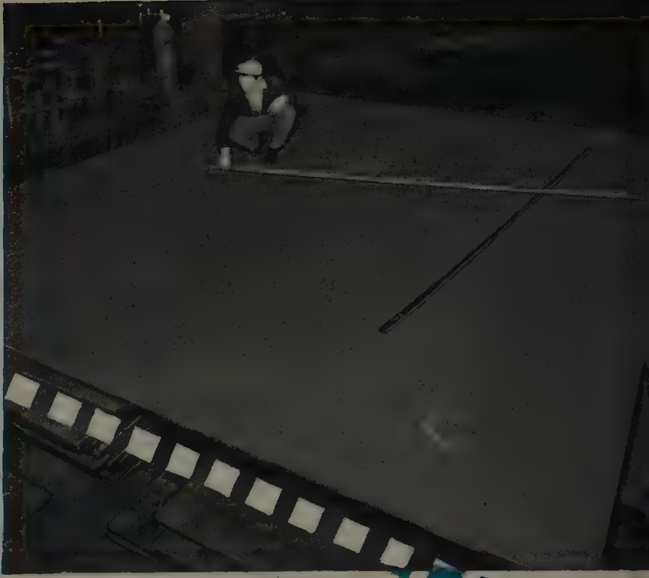
TANK CONSTRUCTION

ANOTHER IMPORTANT PHASE IN THE MANUFACTURE OF

The importance of good tank design and construction is sometimes overlooked by purchasers of power transformers. Tanks which are poorly designed and improperly built can result in extra installation and maintenance expense.

A transformer tank must be a ruggedly-built structure, not only to support the weight of the core-and-coil assembly, oil, and various auxiliary parts, but also to withstand, without distortion, the stresses and strains imposed upon it in shipment and installation.

It is because Moloney has long recognized the importance of proper tank construction, that you will find Moloney transformer tanks particularly well-designed and well-built.



1

Next in line of importance to the engineer's job of de
ing the tank, is that of the layout man in accurately ma
the steel plates and shapes for other workmen to per
the cutting, bending, and welding operations which
vert these materials into a completed tank.

4

In order to support the tremendous weight of a large power transformer the base must be strongly constructed. Here we see the steel reinforcing structure being welded to the tank base. Heavy steel beams and channels prevent distortion and provide weight support, enabling the transformer to be moved on its own wheels or on rollers, without damage.

5

The tank cover must not only provide a weather-proof
tight seal, but must also support the bushings. Photo s
bushing collars being welded to cover. Since bushings
on large, high voltage power transformers are quite l
steel reinforcements are welded to the underside c
cover. After completion of this operation the co
punched for bolting to the tank.

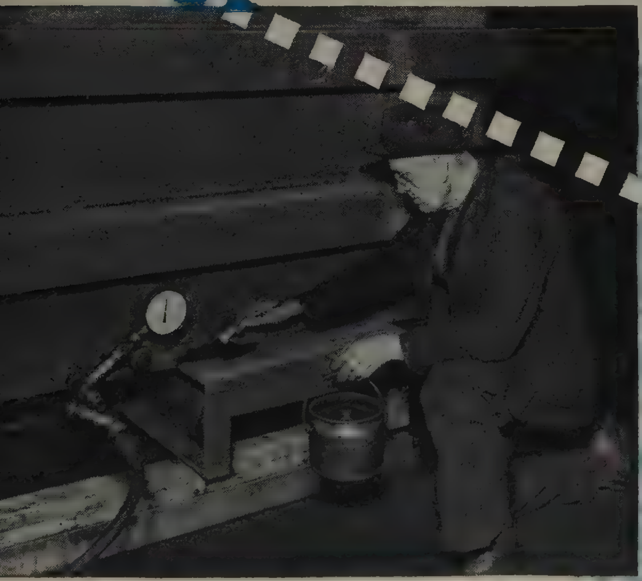
MOLONEY

POWER AND DISTRIBUTION TRANSFORMERS EXCLUSIVELY SINCE 1896 • FACTORIES AT ST. LO

Here we see steel being rolled to form a section of the tank wall. The workman is operating the overhead electric crane holding the steel while the rolls operated by another workman curve the steel plate according to the layout man's markings. As this operation progresses, it is checked again and again until the exact shape specified is obtained.

3

After shaping, the tank sections are welded together by means of automatic seam welders. The seams are welded both on the inside and outside. Shown here is the inside seam welding operation. After this, heavy steel angles or Z bars are welded to the tank wall to provide reinforcement, enabling tank to withstand, without distortion, pressure of the cooling oil and stresses encountered in shipment and installation.



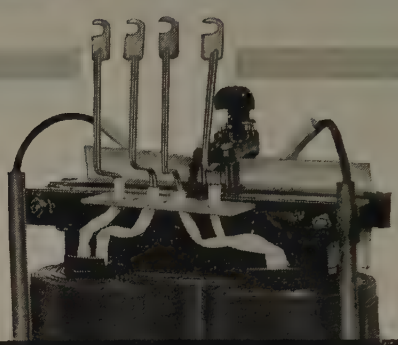
Shown here is the final inspection of the transformer tank. Every welded seam, and every connection point is thoroughly examined for possible leaks under air pressure. The inspector is covering the seams with a liquid which will indicate even the most minute leak. After this careful inspection the tank is completely sand blasted and then painted before the core-and-coil assembly is installed.

ECTRIC COMPANY

URI AND TORONTO, ONTARIO, CANADA.

ALLIS-CHALMERS INSULATES AND PROTECTS TRANSFORMER LEADS

WITH NATVAR 400



Distribution transformers now being manufactured in Allis-Chalmers modern plant in Pittsburgh, are easier to handle and look better because of reduction in size and weight. Electrical characteristics remain the same. The tap changer on this small oil-filled type permits easy voltage adjustment to compensate for loading or length of service entrance. Leads are amply insulated and protected by Natvar 400 extruded vinyl tubing.

With capacity at an all-time high, utilities are doing an outstanding job of keeping up with the relentlessly increasing demand.

Allis-Chalmers distribution transformers, in serving widening areas and areas of increasing density, have handled loads far in excess of their rated capacity for considerable lengths of time without interruption.

Natvar 400, approved for continuous operating temperatures of 105°C., gives lasting insulation and protection to the leads because of its uniformly superior resistance both to high temperatures and to oil.

Prompt deliveries — either from the stock of a wholesaler near you — or direct from our own. Full Underwriters' report on request.

Natvar

Natvar Products

- Varnished cambric—straight cut and bias
- Varnished cable tape
- Varnished canvas
- Varnished duck
- Varnished silk
- Varnished special rayon
- Varnished Fiberglas cloth
- Silicone coated Fiberglas
- Varnished papers
- Varnished tubings and sleevings
- Varnished identification markers
- Lacquered tubings and sleevings
- Extruded vinyl tubing
- Extruded vinyl identification markers

Ask for Catalog No. 21

THE NATIONAL VARNISHED PRODUCTS Corporation

TELEPHONE
RAHWAY 7-2171

CABLE ADDRESS
NATVAR: RAHWAY, N. J.

203 RANDOLPH AVENUE ★ WOODBRIDGE NEW JERSEY

Picture This for Service!

★ DEPENDABLE PROTECTION SINCE 1923 ★

No Moving Parts . . . No Maintenance . . . No Replacement Gas . . . No Bottles to Buy. . . IN 24 YEARS, with Allis-Chalmers *Original* "OIL-SEALED" Inert Gas Systems!

YES, 24 YEARS AGO we built these 18 transformers, totaling 270,000 kva, for a big eastern Utility . . . and equipped them with the *first* "Oil-Sealed" Inert Gas Systems. Today this system is standard for over 5,000,000 kva of U. S. power! What does this pioneering mean to you?

For one thing, when you specify *Allis-Chalmers* "Oil-Sealed" inert gas you buy the *original* system . . . benefit from the longest experience in this field! And you get added advantages over any other type of system:

LOWEST-PRESSURE OPERATION — generally not over 1 lb per square inch. Less pressure on gaskets means lower gasket maintenance.

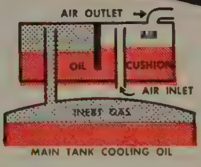
LOWER MAINTENANCE — simple design eliminates sensitive gauges and reduction valves. Periodic replenishment of nitrogen is not required . . . there are no bottles to buy.

YOUR CHOICE OF LOCATION — system may be mounted on top of tank, or on side. ALLIS-CHALMERS, MILWAUKEE 1, WIS.

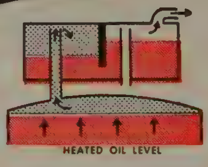
A 2353

"Oil-Sealed" is an Allis-Chalmers Trademark

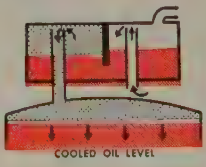
SIMPLE AS A·B·C



A PRINCIPLE — Transformer cooling oil is isolated from the atmosphere by inert gas and oil seal. This prevents sludge formation and fire hazard due to oxygen. Excluding moisture maintains high dielectric quality of oil.



B AS TRANSFORMER HEATS, the cooling oil expands, displacing inert gas from main tank to auxiliary tank. The transfer of gas is cushioned by the change of oil levels as shown, keeping the main tank pressure low.



C AS TRANSFORMER COOLS, the reverse takes place. In this simple manner inert-gas protection is provided automatically . . . transformer oil adjusts itself to changing temperatures without being exposed to the atmosphere.

ALLIS-CHALMERS

Originators of the "Oil-Sealed" Inert Gas System!

These "sound jurors" record their preferences as they listen over test circuits.

Trial by "Sound Jury"

The engineer in the foreground talks over the test circuits which the other engineer sets up on a "circuit simulator."

AFTER Bell Laboratories engineers have designed a new talking circuit, they measure its characteristics by oscilloscopes and meters.

But a talker and a listener are part of every telephone call, and to satisfy them is the primary Bell System aim.

So, before the circuit is put into operation, a "sound jury" listens in. An actual performance test is set up with the trained ears of the jurors to supplement the meters.

As syllables, words, and sentences come in over the telephones, pencils are busy over score sheets, recording the judgment of the listeners on behalf of you and millions of other telephone users.

Targets of the transmission engineer are: your easy understanding of the talker, the naturalness of his voice, and your all-around satisfaction. To score high is one of the feats of Bell System engineering.

BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting for continued improvements and economies in telephone service

The Simplex-ANHYDROPRENE Cable shown is made up of three elements — conductor, insulation and jacket. The stranded conductor is copper, each wire coated with tin or an alloy. The insulation is Simplex - ANHYDREX, a low water absorption, insulating compound. The jacket or outer protection is a thin layer of a tough neoprene compound.

Cables of this simple construction may have solid or stranded conductors. They have no outer braids to rot or fray. They have excellent electrical stability and good aging properties. They resist deterioration by sunlight, heat, acids, oils and they will not support a flame.

Simplex-ANHYDROPRENE Cables are suitable for use in central stations as transformer or generator leads. They may be used for control or signal service. They may be racked on walls without conduit. They may be installed overhead on messenger or pulled into underground ducts.

For more detailed information ask for Bulletin No. 115.

Simplex

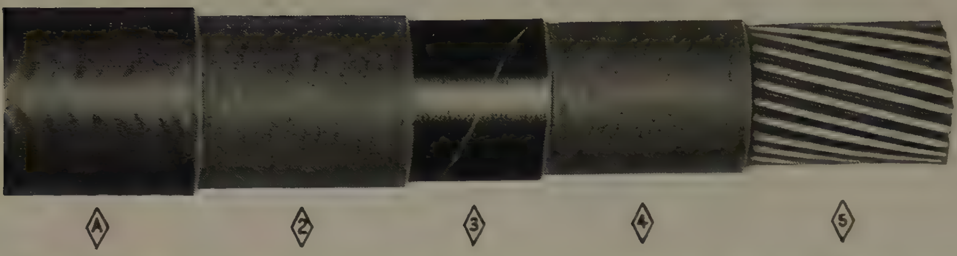
WIRES & CABLES

SIMPLEX WIRE & CABLE CO., 79 SIDNEY ST., CAMBRIDGE 39, MASS.

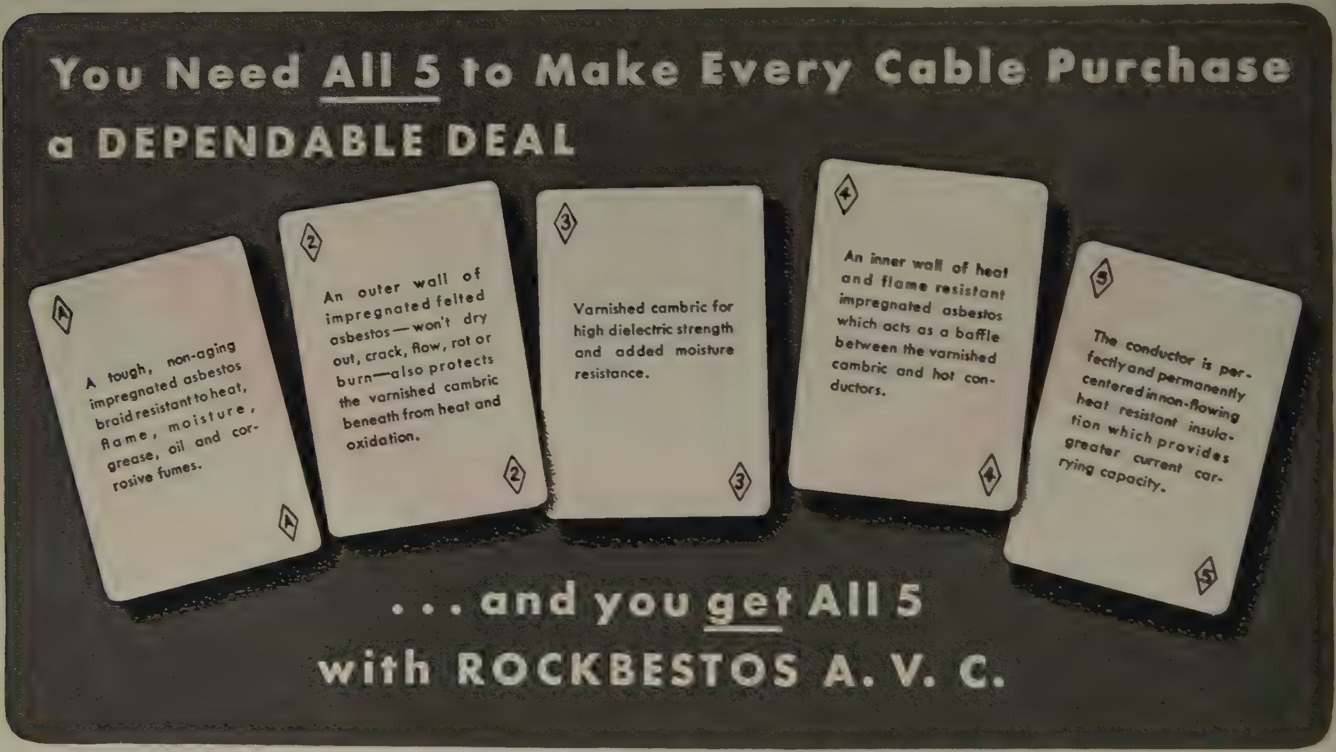
Put Your Money On

ROCKBESTOS A.V.C.

THE CABLE WITH THE PRE-ASSURED Hot Spot PROTECTION



Rockbestos A.V.C. 600 Volt Power Cable—Code Type AVA—will operate continuously under temperatures up to 230° F. This cable and similar types ranging up to 5000 volts *pre-assure* trouble-free performance in hot locations . . . because of the unique 5-point Rockbestos A.V.C. construction.



You Need All 5 to Make Every Cable Purchase a DEPENDABLE DEAL

1 A tough, non-aging impregnated asbestos braid resistant to heat, flame, moisture, grease, oil and corrosive fumes.

2 An outer wall of impregnated felted asbestos—won't dry out, crack, flow, rot or burn—also protects the varnished cambric beneath from heat and oxidation.

3 Varnished cambric for high dielectric strength and added moisture resistance.

4 An inner wall of heat and flame resistant impregnated asbestos which acts as a baffle between the varnished cambric and hot conductors.

5 The conductor is perfectly and permanently centered in non-flowing heat resistant insulation which provides greater current carrying capacity.

. . . and you get All 5 with ROCKBESTOS A. V. C.

Here's the cable that's permanently insulated with impregnated felted asbestos: the insulation that won't lose resilience, bake brittle, crack, dry out, swell, flow, rot or burn—under even the toughest conditions.

This is the built-in Rockbestos A.V.C. protection that gives your installations years of trouble-free performance . . . that takes constant high temperatures up to 230° F. . . . and that withstands severe heating and cooling cycles, fumes, oil and grease—*without failure.*

Engineered for the most exacting installations, Rockbestos A.V.C. wires and cables are available in 600 to 5000 volt ratings—single or multi-conductor—with asbestos braid, lead sheath, armor or lead and armor. Also Type AVA Boiler Room Wire, Multi-Conductor Control Cables, Type AVB Switchboard Wires and Type AIA Wires and Cables.

Get your copy of the new No. 10-F Rockbestos Catalog, sectioned for easy reference—write now.

Rockbestos Products Corp., 233 Nicoll St., New Haven 4, Conn.
NEW YORK BUFFALO CLEVELAND DETROIT CHICAGO
PITTSBURGH ST. LOUIS LOS ANGELES OAKLAND, CALIF.

ROCKBESTOS A.V.C. *The Wire with Permanent Insulation*

RHEOSTATS for every Need

Ten Standard Sizes—25 to 1,000 watts

● You can get a *standard* Ohmite rheostat for practically any application. The Ohmite line of standard rheostats is the most extensive available. Furthermore, six wattage sizes, in many resistance values, are carried in stock for immediate shipment. Special resistance values, tapered windings, tandem assemblies, and many other variations can be made to order quickly at small extra cost. All models are carefully engineered to give long operating life. All have the distinctive, time-proven Ohmite features—the all-ceramic construction, windings permanently locked in vitreous enamel, and smoothly gliding metal-graphite brush. Whatever your needs, Ohmite engineers can provide a rheostat of unfailing dependability to meet your exact requirements.

How to Select a RHEOSTAT

1 UNIFORM WINDING

It's easy to choose the right uniformly wound rheostat if you have certain basic data. Knowing the *resistance* required and the *maximum current* for the circuit (circuit current with rheostat shorted out), the rheostat wattage can be calculated by the formula: $W=I^2R$. A standard rheostat, the wattage of which is not less than the calculated value, can then be selected from the Ohmite catalog. If the resistance and maximum current are not known, Ohmite engineers can calculate them from various circuit information you can supply about the application.

2 TAPERED WINDING

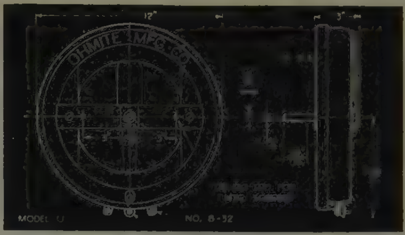
In a tapered winding rheostat the winding is made up of two to six sections of diminishing wire sizes. This construction allows a large resistance change to be "telescoped" into a small part of the winding, thus providing more uniform control and reducing over-all rheostat size.

The design of a tapered rheostat is not as simple as choosing a uniformly wound unit. Taper-wound rheostats can be selected from the standard designs listed in the Ohmite catalog for field control of generators, or Ohmite engineers will be glad to make specific recommendations.

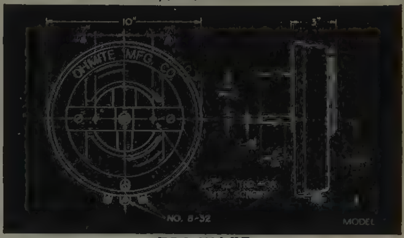
Send for Catalog and Engineering Manual No. 40

Write for this Ohmite Catalog and Engineering Manual on your letterhead. It contains the complete line plus a wealth of engineering information.

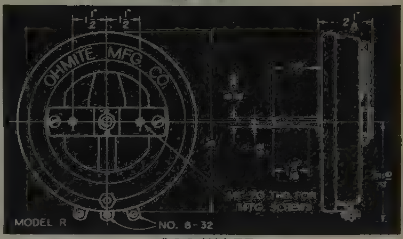
**OHMITE
ANUFACTURING
COMPANY**
4803 FLOURNOY ST.
CHICAGO 44, ILL.



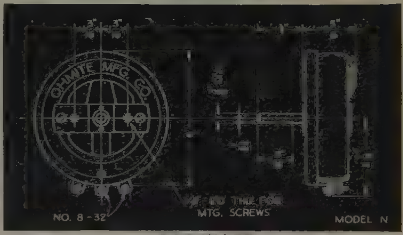
1,000 WATT



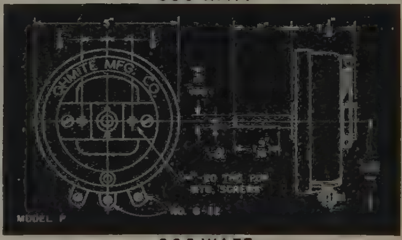
750 WATT



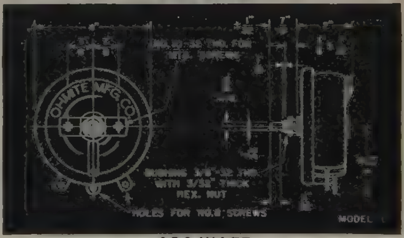
500 WATT



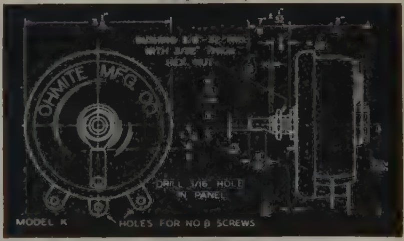
300 WATT



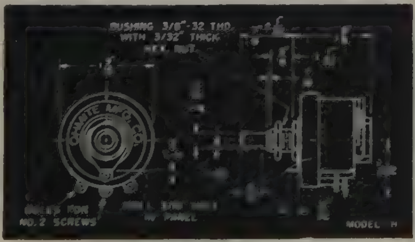
225 WATT



150 WATT



100 WATT



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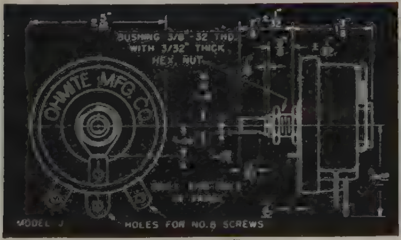
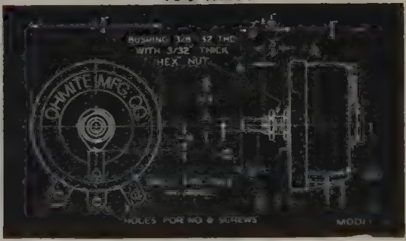
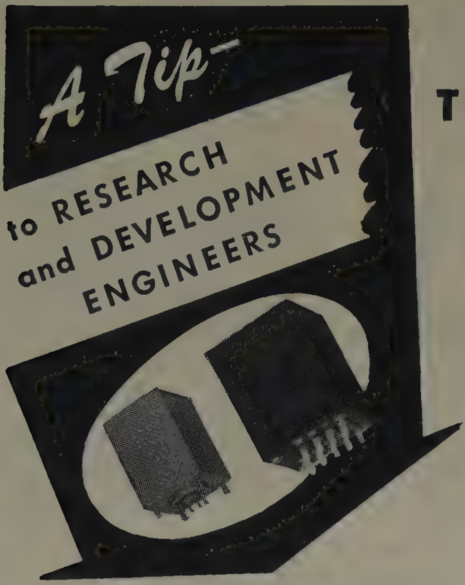


50 WATT



75 WATT

For Unusual and Difficult Requirements



USE ADC TRANSFORMERS

- Research
- Models
- Testing

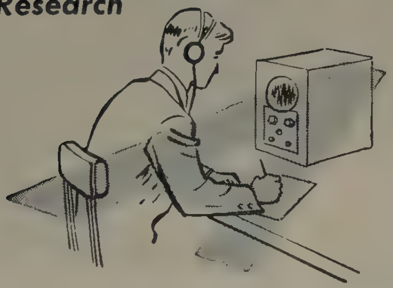
STEEL When a steel company engineer was presented with a problem of testing steel with an application of variable frequency, an oscillator output impedance as low as 0.01 ohms was required over a wide Frequency range.

Through the aid of **ADC** engineers and the use of special **ADC** designed transformers a regular oscillator was equipped to perform the test satisfactorily with great savings in time and money to the steel company. Remember **ADC** as a transformer source for unusual and difficult assignments as well as for high quality and dependable production transformers.

COMMUNICATIONS Today a large utility company has a satisfactory communication system between its central location and its mobile units because **ADC** engineers worked out technical transformer applications for the maker of a power line carrier telephone. From model stage to production this company depended upon the skill of **ADC** transformer design and production. You, too, will find **ADC** helpful in all unusual model work as well as production.

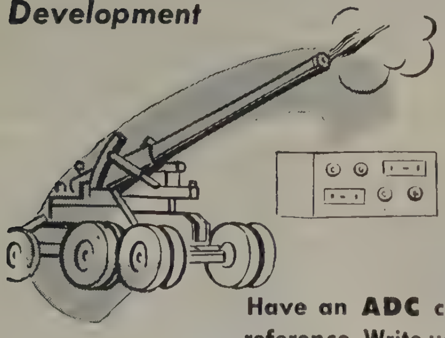
ENGINEERING The development of a computer to check the muzzle velocity of a cannon with greater accuracy required many special transformer applications. This job is typical of scores of development tasks presented to **ADC** engineers from university laboratories, communication developments, guided missile programs and developmental engineers everywhere. **ADC** supplies transformer "know how" with excellent transformer production to assure you a reliable source of dependable transformers.

Research



Models

Development



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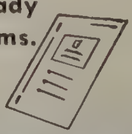

Foreign Inquiries Solicited. Cable address: **AUDEVCO MINNEAPOLIS**

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This significant new book points the road to future research

PREPARATION AND CHARACTERISTICS OF SOLID LUMINESCENT MATERIALS

Published by arrangement with the American Physical Society, under the auspices of the National Research Council. Edited by Gorton R. Fonda, General Electric Company, and Frederick Seitz, Carnegie Institute of Technology.

This volume is the outgrowth of a conference of leading scientists and engineers. They reviewed work of the past and present, and considered possible approaches to new research. The book consists of twenty-nine papers presented, and an account of the discussions which followed.

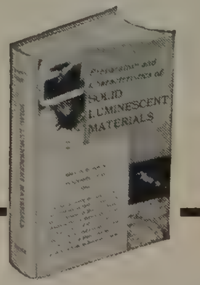
Understanding of Phenomena and Theory of Storage

The book summarizes the information necessary to an understanding of luminescence phenomena, serves as a guide in preparing phosphors, and demonstrates the dependence of luminous characteristics upon measurable features of chemical composition. It explains theories now being used to determine more exactly the processes involved in the storage of luminescence energy, and describes excitation and emission phenomena.

Factors Affecting Fluorescence Characteristics

The book also deals with factors which affect fluorescence characteristics. Measurement, proper organization of experiments, and induction and decay of stored energy are discussed.

1948 459 pages $5.00


Preparation and Characteristics of SOLID LUMINESCENT MATERIALS

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The HATHAWAY type RS-9 Automatic Oscillograph waits to record all the minute details of every system trouble

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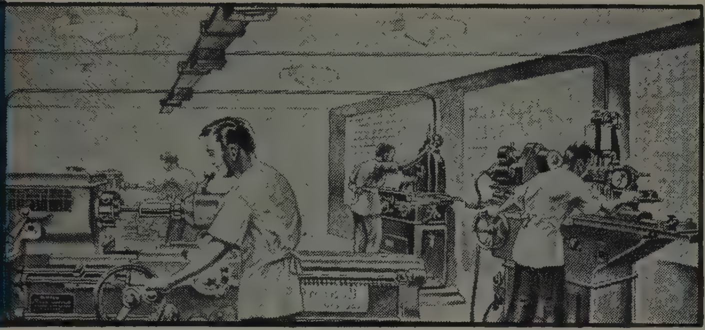
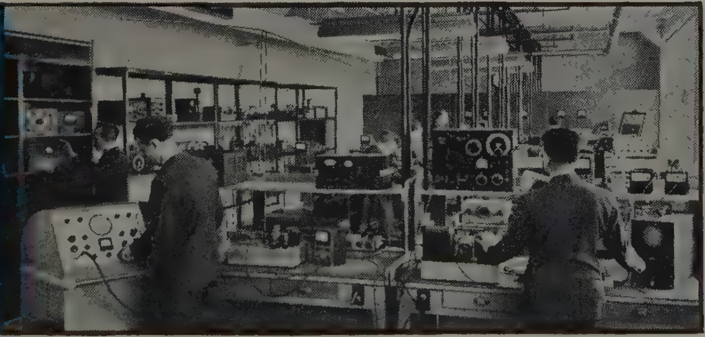
CONSULT SHERRON'S ANALYTICAL ENGINEERING-MANUFACTURING SERVICE

VIEW OF SHERRON ELECTRO-MECHANICAL LABORATORY



In the completeness of its departments, manpower and the skills and experience of its personnel, the Sherron Electronics Co. is organized to meet any challenge in the design, development and manufacture of: Communications equipment . . . Electronic Control equipment . . . Vacuum Tube Circuit development . . . Control of Measuring Devices . . . Instrumentation . . . Television Transmitters . . . Television Test equipment . . . Test Equipment for Components.

VIEW OF SHERRON ELECTRONICS LABORATORY



In broad terms, Sherron's Analytical Engineering-Manufacturing Service means . . . complete design, development, engineering and manufacturing of "precision electronics" equipment. Comprehensive, confidential — this service is exclusively for manufacturers. It is defined by these facilities, personnel and operations:

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ELECTRO-MECHANICAL LABORATORY: Staffed by graduate mechanical engineers fully conversant with the requirements for "precision electronics."

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DIVISION OF SHERRON METALLIC CORPORATION

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- *Trans-Receivers for various uses*
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- *Ample Test Equipment to assure successful operation of above*

ELECTRONIC CONTROL EQUIPMENT FOR

- *Drone Aircraft Guided Missiles*
- *High Gain Amplifiers*
- *Computers and Calculators*
- *Servo Equipment*
- *Velocity Propagation measurement*
- *Test Equipment including Instrumentation for above*

VACUUM TUBE CIRCUIT DEVELOPMENT

- *New applications for existing vacuum tubes*
- *Precision test equipment for vacuum tubes*

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- *Flow indicators*
- *Sorting, Counting*
- *Measurement of chemical titrations*
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INSTRUMENTATION

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- *Null detectors*
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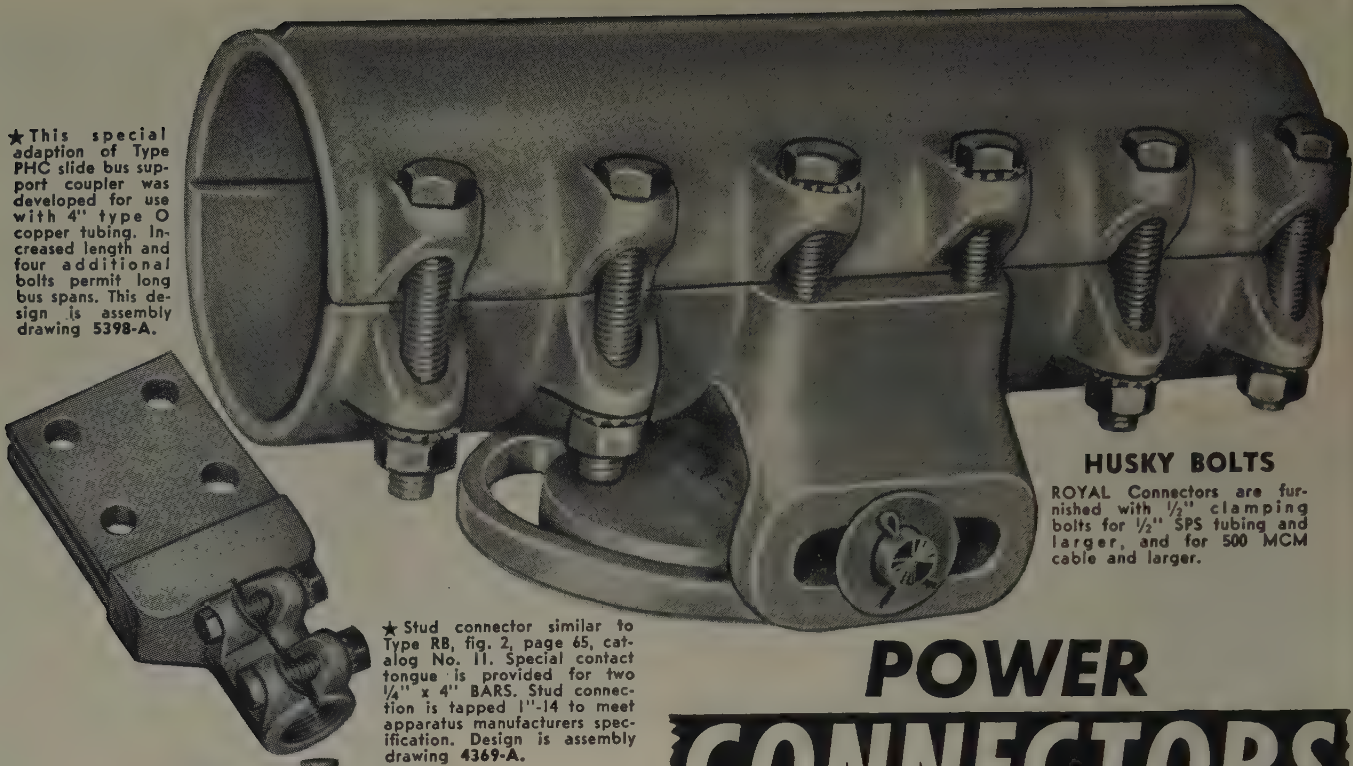
- *Multi-wave shape generators*

TELEVISION

- *Television Signal Synthesizer Sync Generators*
- *Monoscope*
- *Shapers — Timers*
- *Wide band oscilloscopes*
- *Air monitors*
- *Field intensity equipment*
- *Television test equipment*



★This special adaption of Type PHC slide bus support coupler was developed for use with 4" type O copper tubing. Increased length and four additional bolts permit long bus spans. This design is assembly drawing **5398-A.**

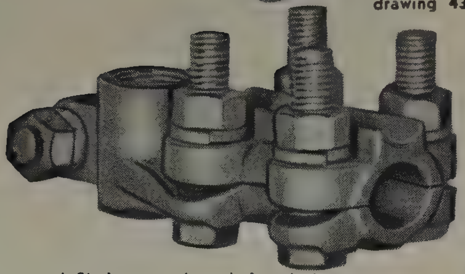
HUSKY BOLTS

ROYAL Connectors are furnished with ½" clamping bolts for ½" SPS tubing and larger, and for 500 MCM cable and larger.

★ Stud connector similar to Type RB, fig. 2, page 65, catalog No. 11. Special contact tongue is provided for two ¼" x 4" BARS. Stud connection is tapped 1"-14 to meet apparatus manufacturers specification. Design is assembly drawing **4369-A.**

POWER CONNECTORS

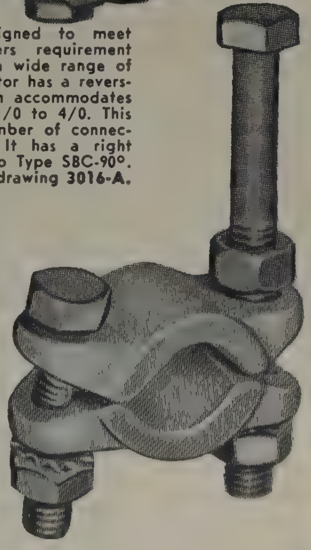
for specific applications . . .



★ Stud connector designed to meet switchgear manufacturers requirement for a fitting to cover a wide range of cable sizes. This connector has a reversible keeper piece which accommodates **No. 6 to No. 1** and **1/0 to 4/0.** This feature reduces the number of connectors carried in stock. It has a right angle take off similar to Type SBC-90°. The design is assembly drawing **3016-A.**

ROYAL'S extensive line of power connectors is tailored to meet individual applications. Your particular standard requirements are easily met. The power connectors shown in our Catalog were developed over a period of years through close cooperation with utility engineers.

Standard listed connectors will not meet every application or requirement. If our Catalog does not show the exact type you require we will produce it for you. Our development and production engineers are ready now to cooperate on any connector problem.

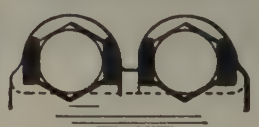


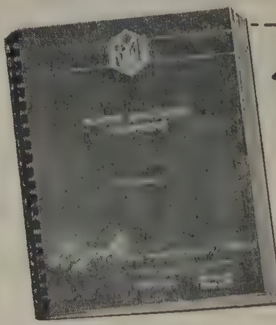
★ This ground or transformer tap clamp was designed at the suggestion of a utility engineer to provide an economical and easy means for making a connection to the station bus. The hot line clamp is attached to the extended arm which can be furnished parallel or 90° to bus. Type DD listed on page 59, Catalog No. 11.

EXCLUSIVE FEATURE . . . .

The bolt heads in Royal Fittings are prevented from turning. One casting is provided with ears which nest the bolt head. This permits the use of standard hex head bolts, readily obtained anywhere. The entering and leaving edges of these fittings are throated. This results in a dampening effect on conductor vibration and eliminates any possible hard spot or localized stress.

NESTED BOLT HEADS





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Send for it

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IN SPECIAL EQUIPMENT

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puts its TOUGH COIL JOBS up to NATIONAL . . . .

NATIONAL introduced MICA-GLAS INSULATED COILS 11 years ago. These years of outstanding performance have proven the worth of MICA-GLAS insulation in armatures and field frames of locomotive motors, machine motors, substation motors and generators, and conveyor and loading machine motors, throughout the mining industry.

NATIONAL MICA-GLAS INSULATED COILS have continuously supplied an economic advantage in lower maintenance costs in the mining industry where operating conditions are inherently difficult.

NATIONAL MICA-GLAS COILS have the heat resistance and the moisture resistance so necessary in the coils and windings of rotating electrical equipment used in the mining industry. *These advantages apply to all other heavy-duty industrial installations.*

NATIONAL MICA-GLAS COILS have proven to be so superior that better than 75% of NATIONAL'S coil production is MICA-GLAS insulated.

REDUCE your MAINTENANCE COSTS with NATIONAL MICA-GLAS COILS—a NATIONAL Field Engineer is nearby.

B

NATIONAL ELECTRIC COIL COMPANY

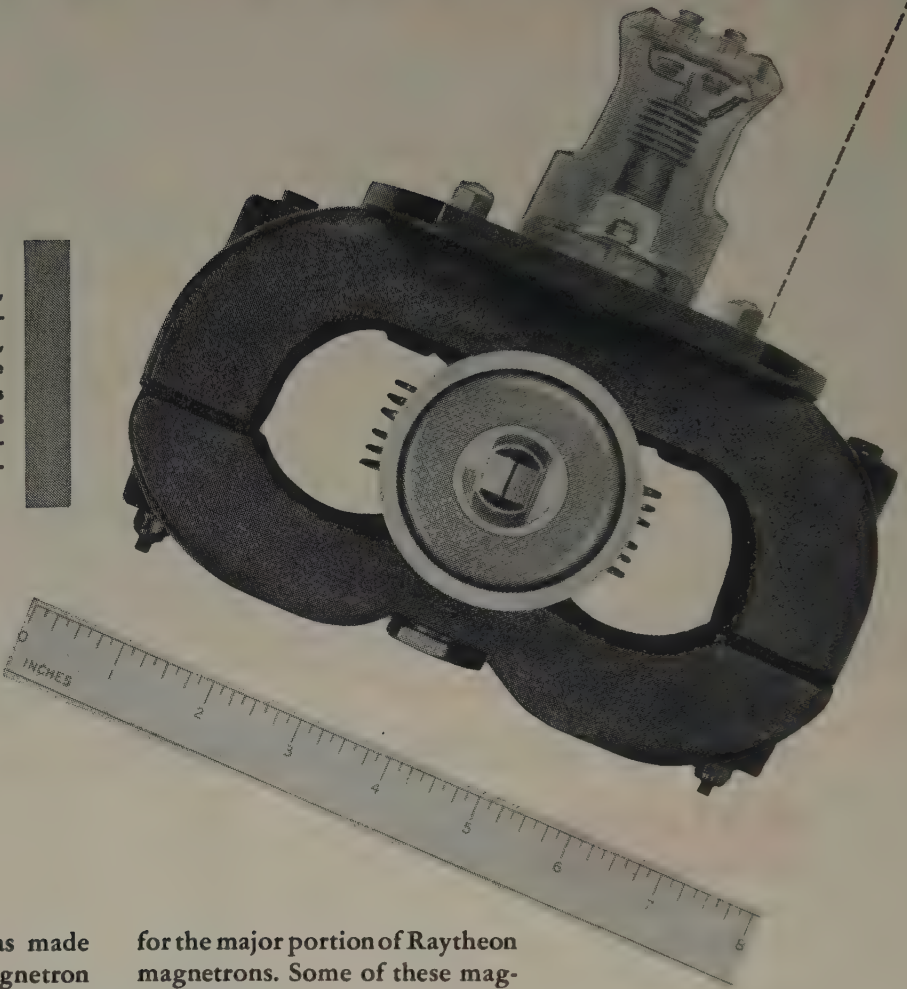
★ **COLUMBUS 16, OHIO, U. S. A.** ★

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

TRADE MARK

Permanent Magnets do it Better in....

RADAR MAGNETRONS



Raytheon Type 4J54-59, 200,000-watt, 5500-megacycle pulsed magnetron, "packaged" to place the magnet pole pieces directly in the tube, thus saving space and permitting use of smaller permanent magnets.

● Micro-wave radar was made practical by operating magnetron tubes in the constant field of permanent magnets. For only with this unchanging magnetic field could frequency stability be obtained. Thus a whole new frequency spectrum was opened up—and a vast new electronic market developed.

Working with Raytheon Manufacturing Company, Waltham, Mass.—producer of more than half of the world's wartime supply of these tubes—our engineers helped design special permanent magnets for the major portion of Raytheon magnetrons. Some of these magnets weigh as much as 50 pounds—in other cases, total weight of the tube-magnet combination is less than two pounds.

OUR SPECIAL DESIGN SERVICE CAN HELP YOU

Every day, permanent magnets are supplying the answers to new and different problems in all branches of science and industry. A discussion with our permanent magnet specialists may assist *you* in new equipment designs—or bring higher efficiency and extra savings in your present products. Write today, Dept. A-6.

ISP

I·S·P *Permanent Magnets offer these benefits*

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- **Unwavering, everlasting strength.**
- **Uninterrupted operation.**
- **No wiring or electrical current needed.**
- **No shock hazard.**
- **No heat produced.**
- **No operating cost.**
- **Minimum installation cost.**
- **Easily installed in original equipment.**
- **Complete range of sizes and materials.**

THE INDIANA STEEL PRODUCTS COMPANY

PRODUCERS OF "PACKAGED ENERGY"
6 NORTH MICHIGAN AVENUE · CHICAGO 2, ILL.
SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

PLANTS { VALPARAISO, INDIANA
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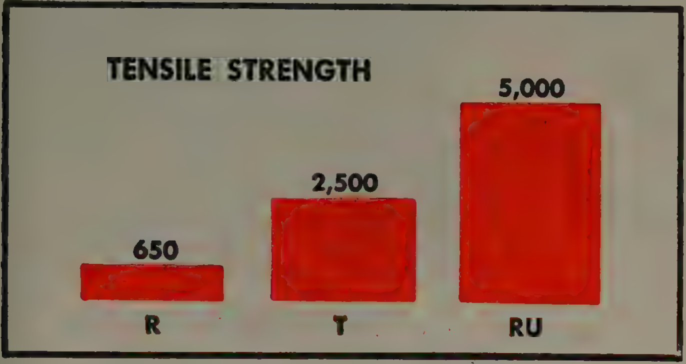
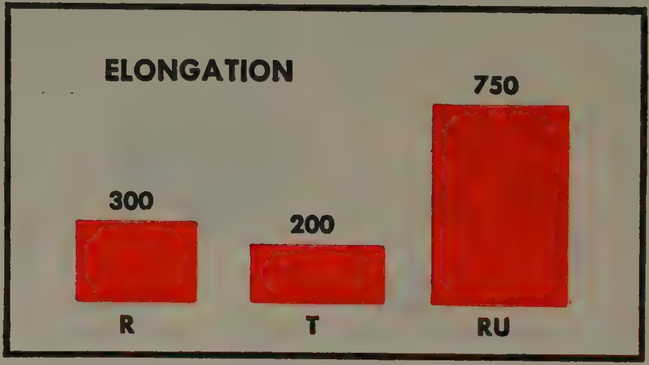
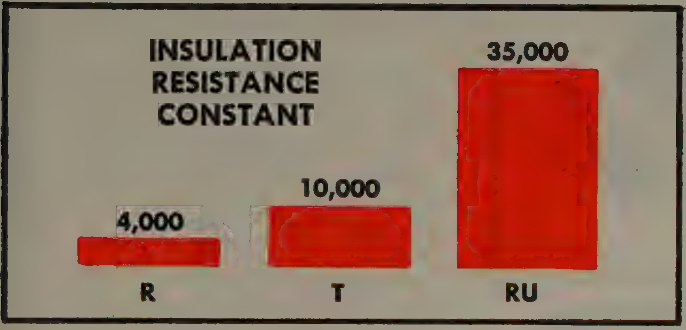
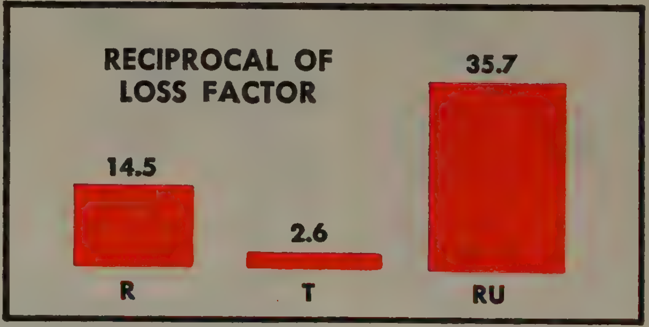
SMALLER DIAMETER CONTROL CABLES INSULATED WITH Laytex*

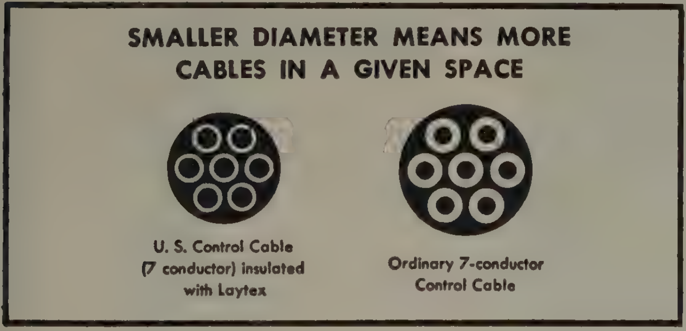
COMPARE Laytex ELECTRICALLY AND PHYSICALLY










SMALLER DIAMETER MEANS MORE CABLES IN A GIVEN SPACE
U. S. Control Cable (7 conductor) insulated with Laytex
Ordinary 7-conductor Control Cable

Three common types of insulation used on the conductors of control cable are:

Type R—The copper conductor has a code rubber insulation.

Type T—A copper conductor with thermoplastic (a synthetic compound) insulation.

Type RU—LAYTEX. This type has a copper conductor, *natural rubber insulation.*

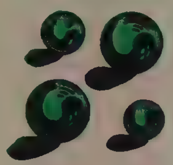
The charts above show the wide margin by which LAYTEX leads in physical and electrical qualities. It is one reason why U. S. Control Cables will continue, as in the past 16 years, to provide the finest service obtainable. For more information, write Wire and Cable Department, United States Rubber Company, 1230 Avenue of the Americas, New York 20, N. Y.

**Reg. U. S. Pat. Off.*

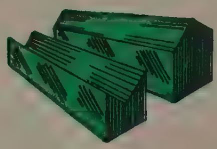
CUP AND RING JEWELS

VEE AND END JEWELS

INSTRUMENT PIVOTS

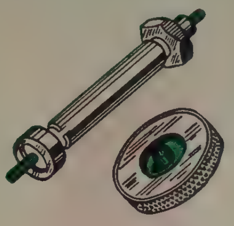


JEWEL BALLS

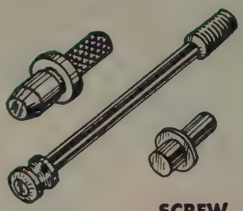


KNIFE BEARINGS

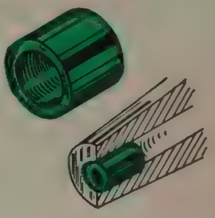
STYLI



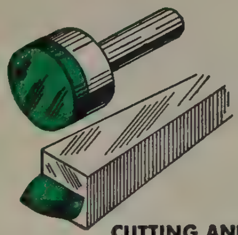
PLUG AND RING GAUGES



SCREW MACHINE PRODUCTS



ORIFICES



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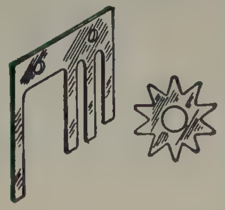

STAMPINGS

HANDS AND DIALS

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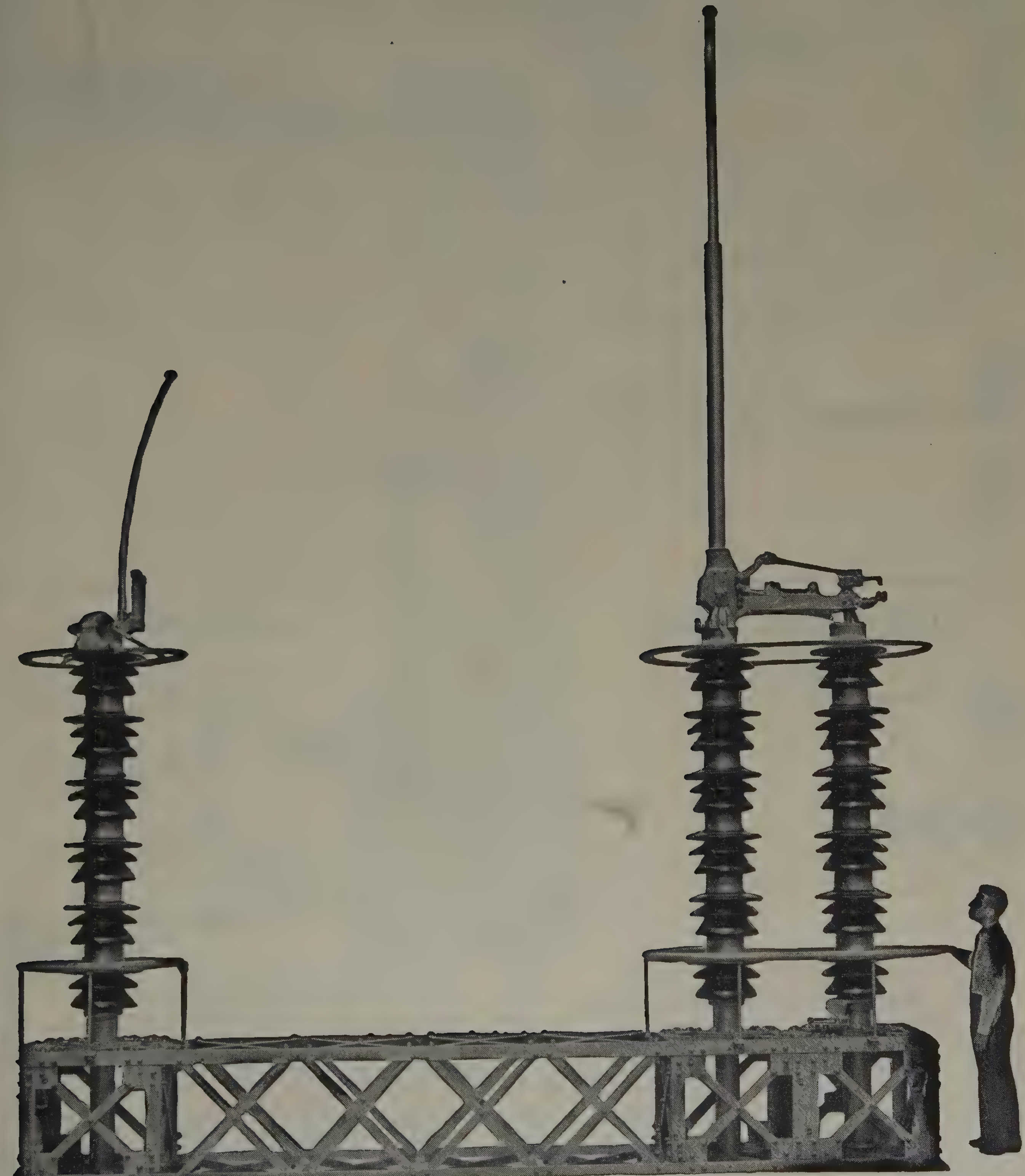


AIRBREAK DISCONNECTING SWITCH
230,000 Volts—1200 Amperes, Type OU, T.P.S.T. Vertical Break, Group Operated. (One Pole Shown)

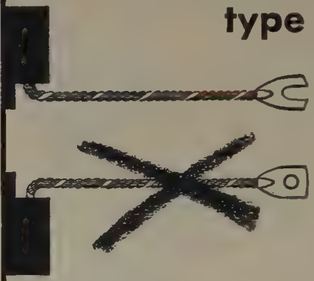
To Reduce carbon brush inventory with "National" brushes!

The lack of standardized specifications has always been the bugaboo of carbon brush applications. Here are ways to simplify these specifications and reduce your inventory.

1. Use only two shunt lengths.

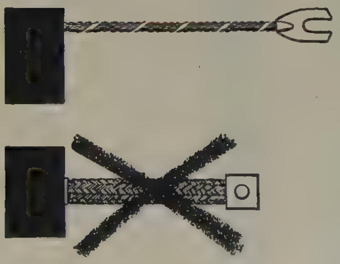
Why specify so many different shunt lengths for identical brushes used on different types of motors and generators? Experience shows that only two shunt lengths—3½ and 5½ inches—are necessary.

2. Substitute slot- for hole-type terminals.



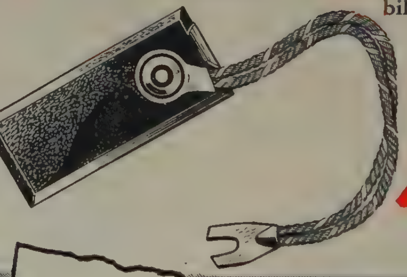
Slot-type terminals are easier to attach to terminal screw. Standardize on the slot-type and you further reduce brush inventories.

3. Use stranded instead of braided cable.



Stranded cable is suitable for any type connection. Braided cable is not suitable for Q-type connections. By standardizing on stranded cable, you gain further inventory reduction.

HOW BRUSH STANDARDIZATION PAYS—



1. Permits buying in economical quantities
2. Fewer small orders—with savings in bookkeeping, billing, and accounting
3. Less money and space tied up in brush stocks
4. Less time needed to handle stock

Why carry hundreds of special carbon brush sizes and types when a few standard brushes will do the job as well?

The term "National" is a registered trade-mark of

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

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SERVICE ENTRANCES
POWER DISTRIBUTION
CONTROL CIRCUITS
INSTALLED • *Direct in Earth*
• *Aerially*
• *In Ducts*
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Developed primarily for underground service, RoMarine-RoPrene is equally suitable for open air or duct installation. One of a few such cables approved by the Underwriters' Laboratories as Type USE-Style RR, it should be your choice where specifications call for residential or industrial service entrances, power distribution and control circuits, indoors or out.

Ro-Marine . . . a low water absorption insulation, assures high electrical stability in the presence of moisture, as well as unusually long life.

RoPrene (Neoprene) . . . as a sheath, provides exceptional resistance to oils, acids, alkalies, weather effects, industrial contamination, as well as the hazards of flame or moisture.

There are definite savings for you in this versatile, multi-purpose cable. It is designed for long life . . . is easy to handle . . . is easy to terminate. Here is a *single* cable for circuits below or above ground, indoors or out . . . without the necessity of splices. Finally, it is Underwriters' approved for 600 volts at operating temperatures up to 60° C.

Write for Specification RR-1 today. It gives you construction details, test data, and available range of sizes.

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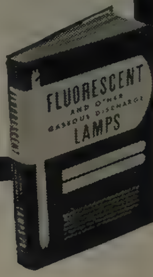

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Here, in convenient form, are essential data for a complete working knowledge of fluorescent and related gaseous discharge lamp types, their physics, theory, present and potential uses, components, construction, advantages, and the engineering problems each presents. In addition to complete coverage of fluorescent lamp physics, the book includes authentic details on recent developments ranging from infrared telescopes and signalling devices to photographic flash lamps, fluorescence in television, sun and germicidal lamps and various others. Throughout, it presents a broad array of factual and experimental data invaluable to any engineer or physicist faced with design or development problems in this fast-expanding field.

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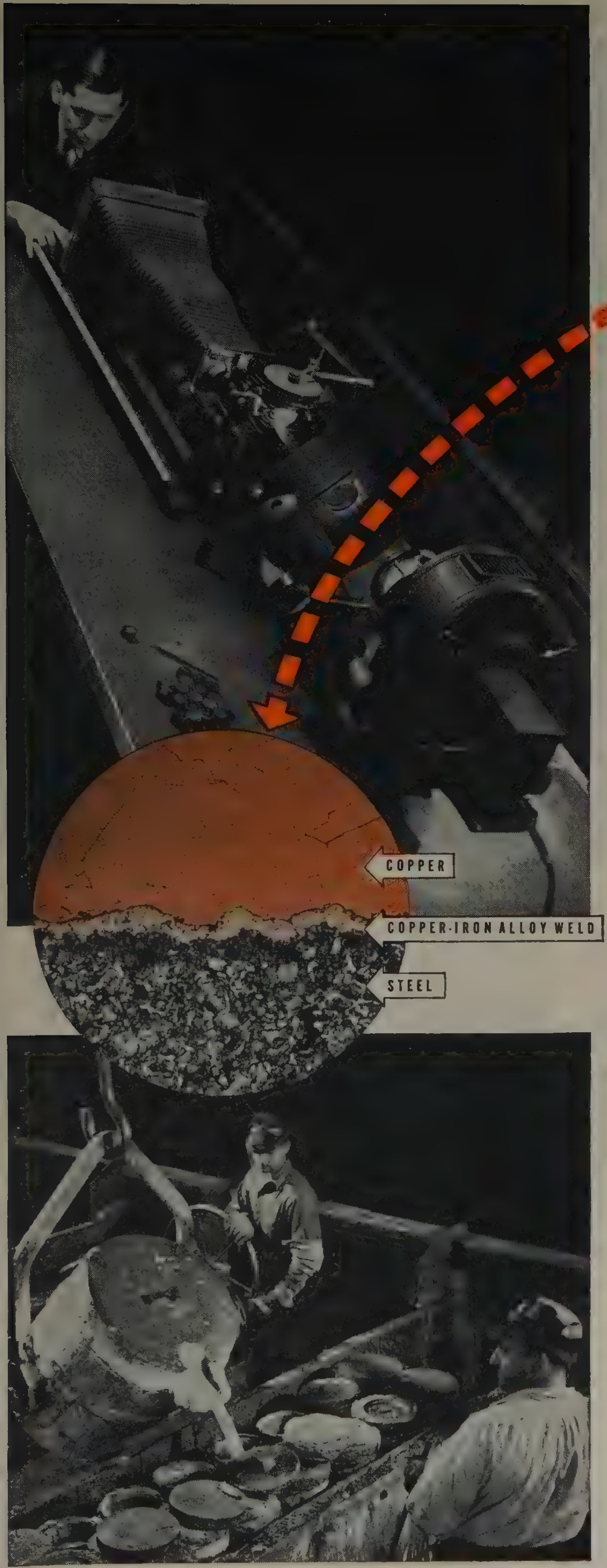

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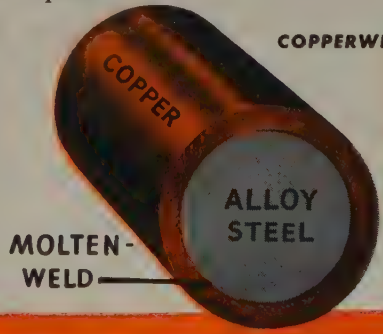

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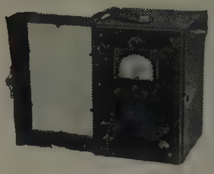

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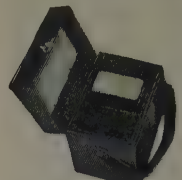

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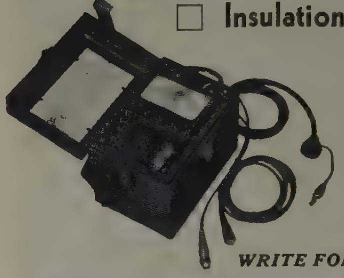

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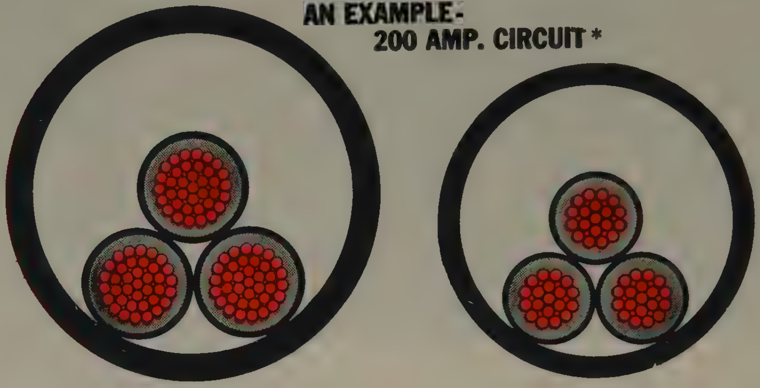

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Requires 2½″ Conduit. Maximum permissible operating temperature 60°C.

3/0
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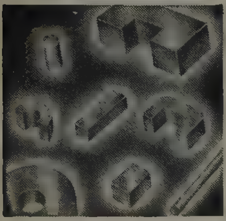

Costwise as well as from a general efficiency standpoint, permanent magnets of Stackpole *Sintered* Alnico II often offer real advantages. Dies for many standard rectangular and cylindrical shapes are available. Beyond these, however, it is practical to adapt magnets of unusual shapes to economical sintered production simply by avoiding reentrant angles and having holes, slots and offsets aligned in the direction of molding pressure. Stackpole can produce specific samples of Sintered Alnico II magnets without dies. This service is freely available to prospective users who send full details of required shapes, sizes, and quantities.

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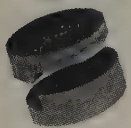

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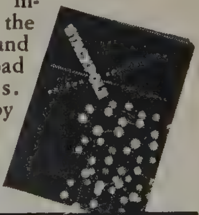

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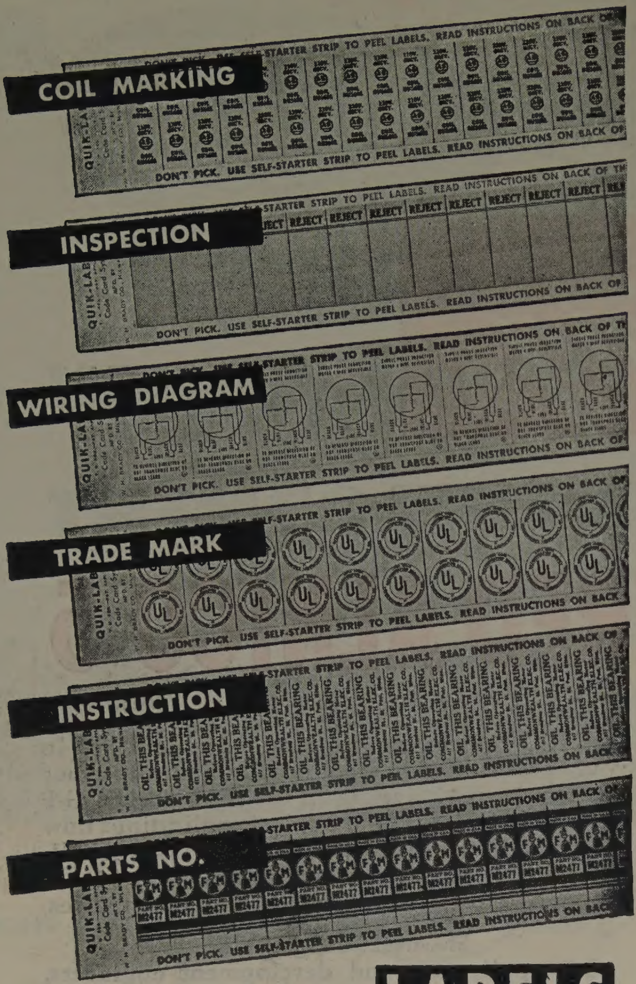
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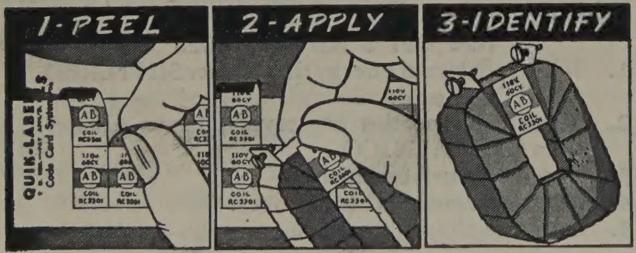

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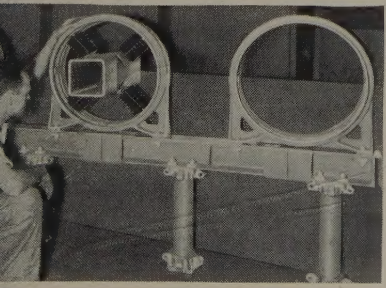
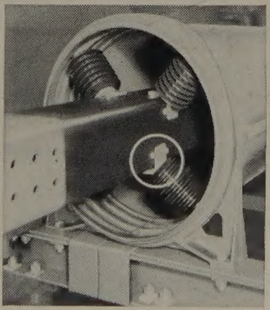
Cast rings mounted on the steel framework support the insulators, conductor, and the bus housing. In I-T-E Isolated Phase Bus, the insulators, with their hardware and mounting devices, form the conductor support. The porcelain insulators are subject to compression stresses only; the support arrangement is so designed that all side forces or cantilever stresses are eliminated. Movement of the conductor because of expansion, is controlled by locking it in certain pre-selected ring positions.

-T-E methods of fabricating, join- and supporting the efficient one- conductor in Isolated Phase Bus t in superior bus structures for application. Catalog 10147 con- s complete information and iptions—send for it today.

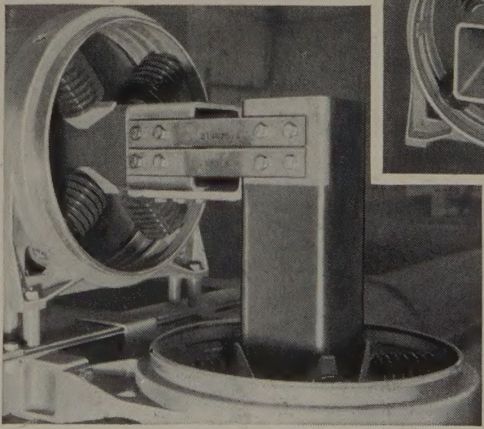


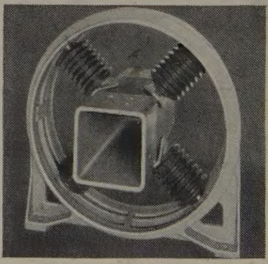


↑ Metal cleats on bus conductor facilitate locking at points where movement must be eliminated.

Standard ring construction ← for I-T-E Isolated Phase Bus Structure.

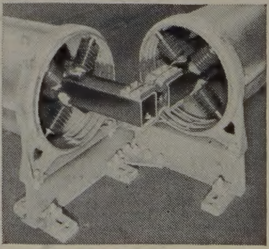
Right-angle solid connection of bus conductor with rigid bars. ↓





← Standard 4 insulator-support arrangement within ring.

Right-angle expansion connection of bus conductor with flexible connectors. ↓



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